FISHERY BOARD FOR SCOTLAND.

SCIENTIFIC INVESTIGATIONS, 1911.

No. I.

NOTES ON SOME SMALL CRUSTACEA FROM THE "GOLDSEEKER" COLLECTIONS.

(WITH 2 PLATES).

BY

THOMAS SCOTT, LL.D., F.L.S.

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NOTES ON SOME SMALL CRUSTACEA FROM THE "GOLDSEEKER" COLLECTIONS.

BY

THOMAS SCOTT, LL.D., F.L.S.

*(With 2 Plates.)**

Preliminary Note.

The Crustacea described here were obtained in collections made by the Fishery steamer "Goldseeker" while carrying on work in the North Sea and adjacent waters under the direction of Professor d'Arcy W. Thompson, C.B., F.L.S., the representative for Scotland on the International Committee. I am indebted to Professor Thompson for permission to publish these notes.

Hemilamprops normani, Bonnier.

1876. *Hemilamprops normani*, Bonnier, Campagne du "Caudan," Edriophthalmes; Ann. l'Univ. de Lyons, p. 546, Pl. XXXIX., fig. 3.

Several specimens which agree very well with Bonnier's description and figures of *H. normani* were obtained in deep-water gatherings from "Goldseeker" Station 53 (Lat. 59°36 N., Long. 7°0 W.), and others from a gathering collected in Lat. 59°25 N., Long. 7°33 W. The telson is moderately stout, rather shorter than the peduncle of the uropods, and with the lateral margins finely but distinctly serrated throughout; the distal half of the telson is also furnished with about seven pairs of stiff lateral spinules, and with five similar spinules at the apex, the middle one being distinctly longer than the others. The length of the entire specimen was about 8 mm., and therefore rather smaller than the size given by Bonnier.

This species has a resemblence to *H. cristata*, G. O. Sars, which was also not uncommon in the "Goldseeker" collections, but was readily distinguished from it by the difference in the armature of the telson.

Diastylis serricauda, sp. n., ♀, Pl. I., figs. 1–4.

In its general appearance this species resembles *D. longipes*, G. O. Sars. The cephalothorax is moderately elongated and equal to rather more than half the entire length. The cephalon seen from the side appears to be of an oval form, and on the dorsal aspect, especially towards the front, are a number of stiff spinules; the rostrum is narrow and somewhat produced in the median line, and the pleon

* The drawings for the Plates are chiefly by my son, Mr. A. Scott, A.L.S.

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segments are rough with minute prickles ; so also is the dorsum of the cephalothorax. The telson is tolerably elongated, being about two-and-a-half times the length ot the last pleon segment, and rather longer than the peduncle of the uropods ; it is subcylindrical for about two-thirds of its length, and then becomes gradually narrower towards the apex. The lateral margins of the distal portion are distinctly coarsely serrated, and the apex is provided with two moderately stout and somewhat divergent spines. The length of the specimen represented by the drawing (fig. 1) is about 12 mm.

Habitat.—" Goldseeker " Station 53 (Lat. 59°36 N., Long. 7°00 W.), at 140 meters, in August 1907. Rare. Pending the discovery of further specimens, and the determination of its relationship with other species, I have ascribed this form provisionally to *Diastylis ;* its most distinct and obvious peculiarity seems to be the form and armature of the telson.

Diastylopsis (*?*) *dubia*, Bonnier. Pl. I., fig. 5.

1896. *Diastylopsis* (*?*) *dubia*, Bonnier, Campagne du " Caudan," Ann. l'Univer. de Lyon, p. 559, Pl. XXX., fig. 3 a—m.

One or two specimens, apparently identical with the form described under this name by Bonnier, were obtained in gatherings collected at two " Goldseeker " stations, viz , Station 53 (Lat. 59°36 N., Long. 7°00 W.), at 1000 meters, in July, and at 1100 meters in Lat. 59°25 N., Long. 7°33 W. in August 1907. The telson in this species, as in *Dic tubulicauda* (Calman), is unusually elongated ; it is cylindrical or nearly so for about three-fifths of its length ; the sides then gradually converge towards the apex, which is narrow and carries two small scarcely divergent spines. The lateral margins of the basal portion of the telson are minutely but distinctly serrated. The uropods, which are slender and do not appear to reach far beyond the telson, have the peduncle narrow and considerably elongated.

Genus *Dic.* Stebbing, 1910.

Dic tubulicauda (Calman). Pl. I., fig. 6.

1905. *Diastylis tubulicauda*, Calman. Fisheries, Ireland, Sci. Investigations, 1894, I. (1905), Cumacea, p. 46, Pl. V., figs. 82–86.

This species was obtained in a gathering collected at 1100 meters in Lat. 59°25 N., Long. 70°33 W., August 17, 1907, and is the only sample in which I have met with it. Perhaps the most obvious character by which this species may be distinguished is the somewhat peculiar form and structure of the telson, and particularly the apical portion of it. The telson is elongated, cylindrical, and not very stout ; its width is about the same throughout, and, instead of tapering at the distal end, it terminates somewhat abruptly in a kind of trifid apex. The uropods are long and slender, but do not reach much beyond the end of the telson. The length of the specimen represented by the drawing (fig. 6) is about 8 mm. Only one or two specimens were observed.

Diastylis tubulicauda was obtained by Dr. Calman in material collected 77 miles W.N.W. of Achil Head, County Mayo, Ireland, at a depth of 382 fathoms (fully 700 meters), but only one specimen was noticed.

Dr. Calman, in describing the species, remarks that "The characters of this peculiar form do not coincide with those of any of the admitted genera of *Diastylidæ*;" and the Rev. T. R. R. Stebbing, in describing a closely allied form for which he has established the genus *Dic.* and the family Dicidæ, alludes to Calman's species and says—"I venture to think that it will prove to be a species of the new genus here instituted."* As the "Goldseeker's" specimens appear to be identical with Calman's species, which in turn agrees so closely with the form described by Stebbing, I have ventured to place it in the genus instituted by that author.

Description of a Large Ostracod.

Genus *Gigantocypris*, G. W. Müller, 1895.

Gigantocypris (?) pellucida, G. W. Müller. Plate II.

1895. *Gigantocypris pellucida*, G. W. Müller, Bull. Mus., Comp. Zoöl., Harvard, Vol. XXVII., No. 5, p. 164, Pl. 1, 6, 7, 11, 16, 22, 23; Pl. 2, fig. 11.

Shell subglobose, rather longer than broad when viewed from the side, but seen in front the width is slightly greater posteriorly. Antennal notch small and near the anterior end. Eyes large, contiguous, and of a brownish colour. The valves are open along the ventral aspect, and about half-way round the proximal end to a little beyond the antennal notch; round the distal end and along the entire dorsal aspect they are closely joined together and almost coalescent, their junction being indicated only by a faint inconspicuous line; they are also apparently unprovided with any hinge arrangement. The valves are chitonous, very thin, semi-transparent, and appear to be without any calcareous stiffening. The animal shows dimly through the shell, and the long vermiform appendages are distinctly seen. The surface of the shell, when viewed under a low power of the microscope, appears to be covered with very minute prickles. Length of the shell, about 15·5 mm. (fully half an inch); width, 14 mm.; thickness, about 12 mm.

The *antennules* are composed of seven joints; the first two are tolerably stout, but the others are slender. The first joint is rather longer than the second, the second and fourth are nearly equal in length, and both are longer than the one intermediate. The fifth joint is rather shorter than the preceding one, and the two end joints are small. Several elongated setæ, some of them ringed, spring from the end joints, but the other joints are only provided with a few short terminal bristles, as shown by the drawing (Pl. II., fig. 5). The formula shows approximately the proportional lengths of the different joints of the antennules:—

Number of the joints,	1	2	3	4	5	6	7
Proportional lengths,	23	15	10	13	11	4	3

The masticatory process on the basal joint of the mandibular foot is undivided, bluntly rounded at the end, and armed with a few short tolerably stout spical spines; the second joint of the mandibular foot is considerably enlarged and provided with a stout appendage, slightly

* Annals of the South African Museum, vol. vi., p. 416 (1910).

curved and spiniform, on its upper distal angle; the third joint is very short, but the fourth is elongated, stout, and somewhat gibbous at the proximal end, and considerably narrowed towards the distal extremity; the end joint is very small and bears two or three moderately long and slender spical spines; the penultimate joint has its upper margin densely clothed with setæ (Pl. II., fig. 7).

Maxillæ.—The first, second, and third pairs of maxillæ are all somewhat similar to the same appendages in *Cypridina mediterranea*, and differ from them only in some minor details. The third pair is provided with four not very clearly-defined lobes, and on the outside of these is a small sub-triangular lamina, with its distal margin boldly rounded and densely fringed with feathered setæ (Pl. II., fig. 10).

The post-abdomen is also similar to that of the species mentioned. Its armature consists of eleven spines; the apical one is of considerable length, while the others become gradually shorter; the margins are all fringed with denticles of a similar kind (Pl. II., fig. 12).

The Vermiform Appendages.—These, which are of great length, are rather slender; the *head* is wedge-shaped and pointed, and the edges of the lips of the jaw-like apex are fringed with minute spinules. These appendages are also furnished at the distal end, and especially near the apex, with numerous long slender bristles such as are usually found on these organs.

Habitat.—Collected by the "Goldseeker" in August 1910, in Lat. 58°43 N., Long. 9°6 W., between 90 and 95 miles W. by N. of the Butt of Lewis, Outer Hebrides, at a depth of about 1448 meters (over 780 fathoms). I have only seen one specimen.

Remarks.—Large Ostracods have been obtained at various times, usually in tolerably deep water, but there has apparently been no record of their occurrence hitherto off the West Coast of Scotland.

The genus *Gigantocypris* was instituted by Professor G. W. Müller in 1895 to include some large Ostracods collected by the U.S. Fish Commission steamer "Albatross" while carrying on dredging operations off the West Coast of Central America. Two species were described—*G. agassizii* and *G. pellucida*, and the specimen recorded here seems to agree fairly well with the latter. Dr. G. H. Fowler, in his account of the Ostracoda obtained from collections made by H.M.S. "Research" in the Bay of Biscay in 1900,* reports the occurrence of two examples of *G. pellucida*, one of which —a perfect specimen—measured about 13 mm. Both specimens were obtained at considerable depths. In recording these specimens Dr. Fowler remarks—"I regard it, however, as possible that *pellucida* is the penultimate stage of *agassizii*."

G. agassizii is apparently a much larger form than the other; Dr. Müller states that "Die Thiere erreichen eine Länge von 23 mm., bei eine Höhe von 19·5, und eine Breite von 18 mm."

Gigantocypris appears to have a wide distribution, for, besides the occurrences mentioned above, Professor Chun, in his account of the Valdivia Expedition, also records the capture of similar specimens in the Atlantic and Indian Oceans, and the Rev. T. R. R. Stebbing, in

* Biscayan plankton collected during a cruise of H.M.S. "Research," 1900; Part XII. Ostracoda. *Trans. Linn. Soc. London*, Ser. 2, Zool., Vol. x., p. 257 (1909).

his report on South African Crustacea, describes other large specimens belonging to the related genus *Crossophorus*, G. S. Brady, which were dredged in deep water 67 and 73 miles S. by W. of St. Blaize, South Africa.* Though the shell of *Gigantocypris*, when compared with the shells of *Cypridinæ*, shows some curious differences in shape and structure, the structure of the animal itself exhibits a somewhat close relationship with that of species belonging to *Cypridina*, and especially to *Cypridina mediterranea*, Claus (*see* Pl. LV. of Brady and Norman's Monogr., Part II.).†

DESCRIPTION OF PLATES.

PLATE I.

FIG. 1. *Diastylis serricauda*, sp. n., female, side view.
,, 2. ,, ,, uropods and telson, front view.
,, 3. ,, ,, ,, ,, side ,,
,, 4. ,, ,, end of telson, more highly magnified.
,, 5. *Diastylopsis dubia*, Bonnier, uropod and telson.
,, 6. *Dic tubulicauda* (Calman), uropod and telson.

PLATE II.

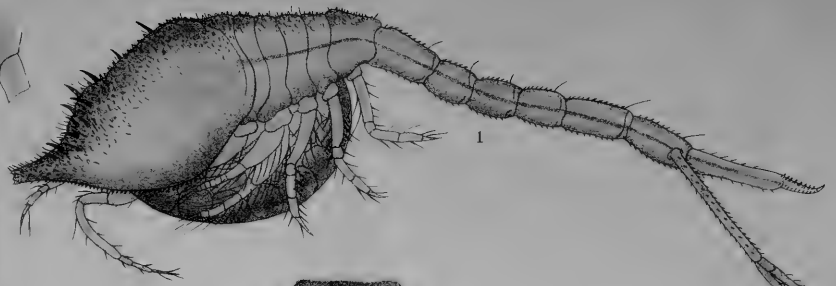
Gigantocypris (?) *pellucida*, G. W. Müller.

FIG. 1. Shell, side view.
,, 2. ,, front view.
,, 3. Antennal notch, front view.
,, 4. Cross lines to show natural size.
,, 5. Antennule.
,, 6. Antenna.
,, 7. Mandibular foot.
,, 8. First maxilla.
,, 9. Second maxilla.
,, 10. Third maxilla.
,, 11. Vermiform appendage.
,, 12. Post abdomen.

*Marine Investigations in South Africa—South African Crustacea, Part ii. (1902), p. 79, Pls. 15A and 16; also Annals of the South African Museum, vol. iv., Part iv. General Catalogue of Crustacea, p. 518 (1910).

†A Monograph of the Marine and Fresh-water Ostracoda of the North Atlantic and North-Western Europe, Part II., *Trans. R. Dub. Soc.*, vol. v. (Ser. II.), No. XII. (1896).

Plate I



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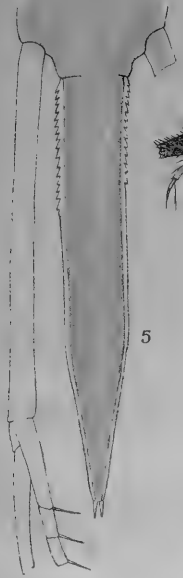

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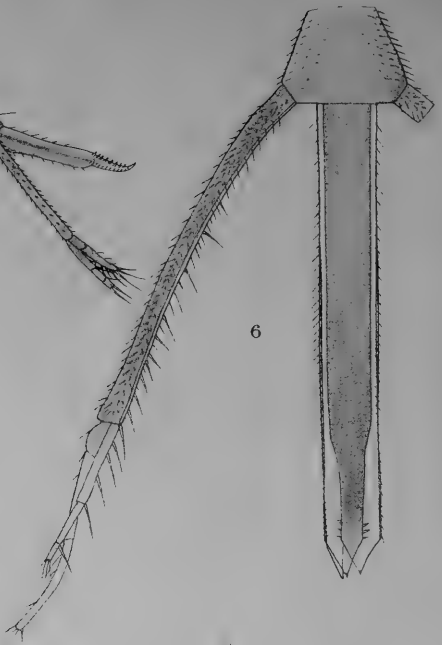

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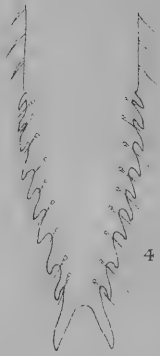

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Figs. 1-3 A.Scott, del. Figs. 4-6 T.Scott, del.

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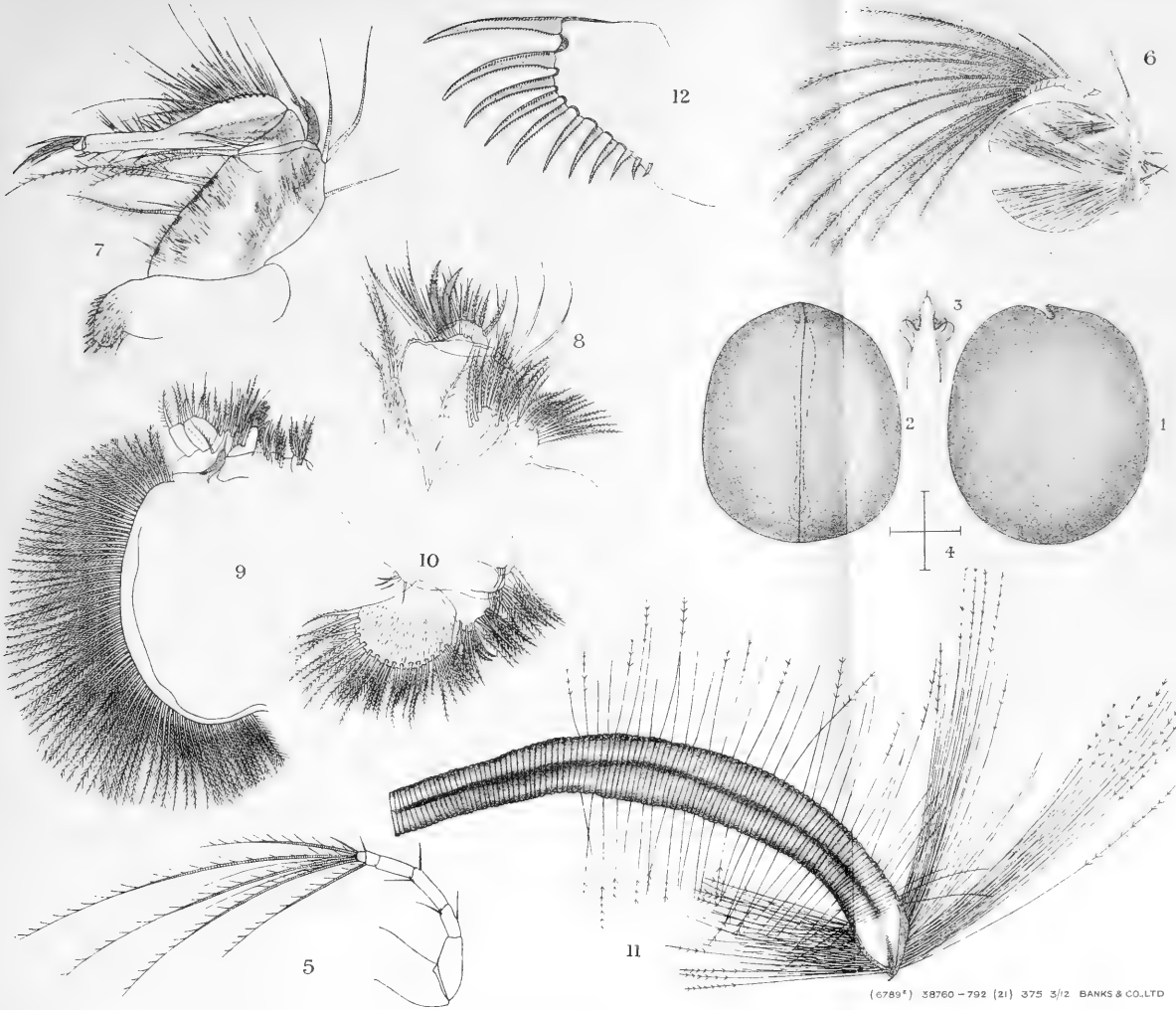

A.Scott. del.

GIGANTOCYPRIS PELLUCIDA J.W.MÜLLER.

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FISHERY BOARD FOR SCOTLAND.

SCIENTIFIC INVESTIGATIONS,

1911.

No. II.

REPORT ON DISEASES AND ABNORMALITIES IN FISHES

(WITH 8 PLATES).

BY

DR. H. C. WILLIAMSON, M.A., F.R.S.E.,

MARINE LABORATORY, ABERDEEN.

This Paper may be referred to as:
"*Fisheries, Scotland, Sci. Invest., 1911*, II." (*March 1913*).

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FISHERY BOARD FOR SCOTLAND.

ON DISEASES AND ABNORMALITIES IN FISHES OF THE COD (*GADUS*), FLAT-FISH (*PLEURONECTES*), SALMON (*SALMO*), SKATE (*RAIA*), ETC., FAMILIES.

BY

H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E.,
MARINE LABORATORY, ABERDEEN.

(*Plates I.–VIII.*)

CONTENTS.

Diseases and abnormalities are common in fishes. They are in many cases due to parasites. I have from time to time received a considerable number of abnormal specimens, and for these I have been indebted, in large measure, to the courtesy of Mr. W. S. Eunson and Mr. B. Erlandson, Aberdeen.

In the following pages I describe a number of diseased conditions. They include instances of tumours, parasites located in the muscles, kidney, and liver, deformities of the vertebral column, etc.

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Dokus adus—An Intracapillary Parasite of Fish.

This parasite occurs not infrequently in the muscles of the haddock (*Gadus æglefinus*); it gives rise to the condition known as the "spotted haddock," "greasers," or "smelly haddock." The disease is not to be detected on the outside of the fish. It is only when the fish has been split, as, for example, in the preparation for curing, that it becomes visible. The parasite is then seen to consist of little white bodies (cysts), measuring 1 to 2 mm. in length, scattered through the muscles (C, fig. 7).* It is often observed in haddocks captured off the West Coast of Scotland. It is said to occur in North Sea haddocks also, but that statement is questioned. When smoked the infected fishes have a disagreeable smell. The fishes exhibiting the parasite which have been examined for the present paper measured from about 12 to 18 inches (30–43 cm.) in length. They appeared to be in good condition.

The cyst tends to lie in the run of the muscle fibres, which it has pushed aside to form a cavity. Fig. 2 represents an enlarged view of a cyst *in situ*. It consists of what looks like a mass of spores situated in chambers of various sizes. Here and there about the cyst, or apart from it in the muscles, can be seen elongated larvæ (*a*). These are larvæ which have wandered from the cyst. The enveloping tissue of the cyst seems to be connective tissue formed by the host. Such a cyst as is shown in the figure is probably formed of many cysts, which may, however, have been derived from a single original cyst. The apparent spores are not spores. They are branches of the parasite which are situated in pouches pushed out from the original cyst. The flesh of the parasite is granular and rather opaque. At two points in the large cyst greenish-yellow areas were seen, viz., bl. One of these regions is shown in greater magnification in fig. 3. Spindle-shaped bodies are to be observed in the area. These I am inclined to interpret as blood corpuscles.

The cyst can be dissected out whole from among the muscles; it is bound only very slightly to the muscles. It is bathed in a sticky plasma that coagulates in water. Figs. 11 and 16 are enlarged drawings of cysts. When the cyst is teazed up the chambers may break off separately, bringing with them portions of the parasite. The chambers then resemble spores (cp., figs. 8, 9, 14). Fig. 8 shows the different parts of the chamber; w. is the wall of the chamber; pa. is the parasite, which has an outer skin; ct. is the connective tissue which forms the investment of the cyst. The chambers show a pore in the wall. They are of various sizes, some being very small. In a large chamber ·05 mm. in diameter the part of the parasite filling it exhibited vacuoles (fig. 14). It is probably an encysted larva.

The great development of connective tissue is seen between the muscle fibres (fig. 1). Where the thickened connective tissue covers the muscle it hides it, rendering it opaque (ct. *ib.* and m'. fig. 4). Where the normal amount of connective tissue is present the muscle fibres are clearly visible. The muscle fibre *m.* shown in fig. 1 was about ·2 mm. in breadth.

The wandering larvæ are found in tubes either as elongated forms (*a.* figs. 4, 10, 15, 20), or as round ovum-like bodies (*la.* fig. 22). A

* A haddock exhibited, to the naked eye, black flecks through the muscles. The flecks were collections of minute black granules. Some larvæ of *Dokus adus* were detected by means of the microscope.

nucleus (or vacuole) was made out in the larva shown in fig. 15. The largest larva in fig. 4 measured ·12 mm. in length. The tubes in which the larvæ are situated communicate with one another. In some cases the termination of the tube could not be clearly made out, *e.g.*, figs. 20 and 176. The ovum-like body is, I think, the elongated larva encysted. In fig. 35 the larva appeared to be giving off a bud, while what looked like a little detached bud was seen at '*a*.' No movement was detected in any of the larvæ. The encysted larvæ are opaque, and are enclosed in a thin wall, *e.g.*, op., fig. 20, but translucent capsules having a thick investment are present (fig. 27, and tr., fig. 29). In the latter case the contents of the capsule (tr.) seem to have been lost. I think this thick-walled translucent capsule is a later stage of the encysted larva; it is larger in some cases and smaller in others than the encysted larva. It will probably develop into the condition shown in fig. 36, and further into the "columnar body" to be described below.

Two of the encysted larvæ were tinted with green colour. The two cells in fig. 28 were in the muscles apart from the cyst. They were smaller than the encysted larva; they contained round corpuscles. At a little distance away from the main cyst little green bodies were observed. They were bundles of green spore-like corpuscles. A capsule was attached to the green body.

In a second stage of the cyst the wandering larvæ are seen to have pushed their ways in every direction out among the muscle fibres. Fig. 5 represents such a cyst. Under the dissecting lens the encysted larvæ (*a.*) are seen surrounding the cyst. If the cyst is dissected out from the muscles the tubes break off, leaving the larvæ in their places. The cyst measured 1·1 mm. in length in the run of the muscles. Fig. 22 shows a group of three larvæ. The largest measured ·07 mm. in length. The larva, even when away from the cyst, is covered with the thicker connective tissue.

Some of the cysts show in addition columnar bodies (*col.*, figs. 5, 11, 179). The columns are not muscle fibres. They are somewhat translucent, colourless, and they are crossed by wavy lines. In some cases the columns were somewhat dried up, *e.g.*, fig. 16, but they are bathed in a sticky plasma. When the column was teazed a powdery material was obtained in addition to parts of the parasite. Muscle fibres are bound up with the columns. I did not make out any ova or spores in the columns. The column would seem to be the final stage of the parasite.

A small oval-shaped body, ·2 mm. in length, separated from a cyst by a little distance, is evidently the beginning of a column (fig. 178). Fig. 6 represents the section of a cyst from the same fish. The cyst measured, from x to y, 1·5 mm. The cænosarc of the parasite is shown dark. Some of the chambers are empty. A wandering larva is shown at *f. a.* Various columnar bodies (*col.*) are present. Fig. 36 shows what appears to be an early stage in the formation of the column. The largest of these columns in fig. 179 was 1·9 mm. long and ·25 mm. wide. The columns may be moulded in part by the muscle fibres.

A noteworthy fact is the extensive infection of the fish. This indicates that infection probably takes place through the blood system. The parasite does not feed on the muscles; it derives its

provender from the blood supply. The kidney was found to be infected with the same parasite, and at the same time the spinal nerves were laden with the cysts of *Gasterostomum gracilescens.* The cysts of this trematode when present in the skin of the whiting are surrounded by black pigment,* and thereby give the skin a spotted appearance. Gamble and Drew state that this condition is due to the presence of a trematode, probably *Holostomum cuticola*, v. Nordmann, which causes a similar infection in German cyprinoids. Some of the cysts measured ·5-·6 mm. in length. In order to discover how far this dual infection occurred, 27 spotted haddocks † were examined. In 26 of these the parasite was found in both muscles and kidney, and *Gasterostomum gracilescens* cysts were present in the nerves. In the remaining fish the condition in the kidney was not noted, but the muscle and nerves were infected by the respective parasites.

In the kidney the cysts were generally smaller than in the muscles, and they were attached to a green thallus-like body (*th.*, figs. 19, 173). The cyst in fig. 19 measured, from x to y, ·6 mm. The thallus has a structure: it is not a smooth plasma. It is amber-coloured, and it has scattered through it dark brown bodies (*b.*, figs. 173, 174). These dark brown bodies are also to be seen out in the tissue of the kidney apart from the cyst (fig. 33); they measure roughly about ·01 and less in diameter.

The branched parasite is shown in figs. 18 and 174. In the latter case it consists of seven branches. From other cysts, three and four larvæ are found to have wandered (figs. 24 and 30). In fig. 177 fifteen branches (*a.* larvæ) are seen, but their relation to one another was not definitely made out. The larva in the kidney measured practically the same size as those in the muscles, viz., ·12 mm. No. 2 in fig. 30 (larva *a.*, fig. 177) measured ·12 mm. in length, while *p.*, fig. 19, was ·1 mm. long. A little branched form is shown in fig. 23. It was found detached and a little distance away from fig. 24.

The "thallus" varies in size. A comparatively large one is shown in fig. 173. It measured about ·25 mm. in length. The cyst is attached to the thallus and is probably deriving sustenance from it. This cyst in greatest diameter measured ·12 mm. The spindle-shaped bodies (*cr.*) present in the thallus, and also in the kidney tissue, are, I think, crystals. The cyst is thick-walled and contains five chambers at least. Two of these are empty (*e. ch.*) The wrinkles in the envelope assume a very characteristic form (cp., fig. 21). In some cases the thallus had no cyst attached, *e.g.*, th, th′, th″, fig. 30. In this drawing a larva (2) is seen to have arrived (?) at a thallus, viz., th′. In some cases there is only one chamber visible in the cyst, (figs. 24 and 34). It is possible that the walls of the chambers may have collapsed.

The kidney tissue does not appear to be broken up near the parasite; still, the more the kidney is infected the more fluid it appears to become. There are some small amber-coloured centres filled with greenish amber corpuscles.

Little green corpuscles were observed in the kidney tissue (g., fig. 32); *b.* in the same figure, is a dark brown body.

A little green thallus with a capsule attached was observed in the muscles also.

* Williamson, H.C.—"Notes on the Eggs of Angler, etc."

† Mr. Geo. Angus kindly supplied some of these fishes.

Is the thallus formed independently of the larva? Does the larva merely feed upon the thallus? Or does the thallus grow on to the larva? Might the thallus be derived from the breaking up of the blood? Is a part of the columnar body analogous to the thallus?

The following appears to be the description of the parasite:— The larval parasite enters a capillary blood vessel and lodges there. It grows larger and, as it does so, it pushes out the wall of the capillary in a series of pouches for the accommodation of its increasing bulk (*pa.*, fig. 13). At the point where the capillary is blocked by the parasite the vessel is distended to form a blood cyst (*s.*) The branches of the parasite eventually separate off and wander as elongated larvæ further along the capillary, following its branches. The larva was not observed to move, and it is probably forced along the capillary by the propelling action of the heart. It then assumes a spherical form, thereby no doubt blocking the capillary (fig. 175). This encysted form seems to grow into a columnar body. The capillaries occupied by the parasite are filled with a translucent fluid (serum). The part of the vessel occupied by the parasite becomes surrounded by a thick development of connective tissue.

In the stages described above I observed no spore-formation. The form cannot therefore be definitely regarded as a sporozoan. It shows, however, some points of resemblance to stages in certain Myxo-sporidia. Bertram's drawing * of the cyst of *Sarcocystis tenella*, found in the muscle of the sheep, has a general resemblance to the cyst in the spotted haddock. The plate of figures of Pfeiffer's Myxobolus sp.† also recalls in some respects the present parasite. But the former is said to penetrate the muscle cell. Johnstone's drawings of a fungus found in the viscera, kidney, and mesenteries of the plaice resemble certain portions of this parasite.

I have regarded this parasite as undescribed, and I propose the name *Dokus adus* for it.

Diseases in Cod (*Gadus callarias*).

Green Parasite (*Roles trelis*, n. sp.).—The muscles were green-coloured, as if with a dye, at one part. The stained portion was in the muscles resting on the dorsal side of the lateral processes of the vertebræ. It measured 1 inch (2·5 cm.) in length by ½-inch (1 cm.) in breadth. Figs. 65 and 76 show sections of the region. A broad line of dark green (l.) crosses the muscle. It seems to run along an aponeurosis. The muscles on either side are stained green (shown shaded in the figure). The stain extends well all round and gradually gets fainter as it recedes from the central line. Along the central part the parasite consists of dark green bodies. Little brown bodies are seen scattered through the muscles in the fringe of the greenish area. There is another centre (p.) with little elongated bodies of a dark green colour, and outside them other bodies brown in colour. The brown bodies are in the connective tissue between the muscle fibres.

The muscle fibres did not appear to be stained nor affected by the parasite. The connective tissue is increased in quantity round the parasite, and it appears to be stained.

Fig. 64 is a drawing of a small part of the parasite. A number of

* *Vide* Braun. † *Vide* Gurley.

dark-green embryos are seen enclosed in what appear to be vessels. In the figure the green embryos are shown shaded. Surrounding the embryos there is an amber matrix (*br.*) The embryos are opaque, but segmentation can be made out. The long embryos had usually no brown matrix round them, although a brown colouration was observed near one. They are enclosed in a tough vessel, which shows branches. None of the embryos were made out to be mobile. The parasite grows into long green columns. Fig. 71 represents a portion of the parasite. The green columns are made up of large round cells, so far as could be made out. The columns are bound together. The part of the vessel in front of the column is very narrow (*v.*) The green bodies are sparkling bright under the microscope. There are in some cases yellow cells inside the columns. They are, I think, blood corpuscles inside the vessel and surrounding the green columns.

What is evidently an early stage of the parasite is shown in fig. 68. I do not think that the space in which the ovum rests should be regarded as merely an intermuscular space.

Fig. 72 is a drawing made of a section of the parasite. Several columns are shown cut across. Yellow cells (blood corpuscles) are seen at *y*. Between the muscles at *r*. the connective tissue is slight and light in colour. At the right side it is denser.

On teazing up the muscles a row of white granular bodies running along between the muscle bundles and scattered over the muscle were seen.

A capsule found detached among the fibres measured ·3 mm. in outside diameter (fig. 77). It had a thick cyst wall enclosing an ovum which had a green embryo. The ovum measured ·17 mm. and the green embryo about ·07 mm. in greatest length. The capsule is white to the naked eye. There were traces of segmentation in the embryo and ovum. The rind of the capsule was a soft fluffy layer in which hardly any structure could be made out, but it was covered with minute refractile granules. The capsule was quashed (fig. 74). The green embryo (*n.*) appeared to be composed of small cells. It was enclosed in a soft cellular mass (*ce.*), while outside was the soft rind (*ol.*).

When the fibres are torn apart the parasite is sometimes ruptured. Along the central part of the infected area, which was attached to a broad aponeurosis, there was a great mass of fibrous tissue which enclosed buds and green columns in a big mass.

I have not been able to find that this parasite has been already described, and I propose for it the name *Roles trelis*.

Columnar Disease.

A small cod was infected throughout its muscles with amber-coloured bodies. They were bundles of hard columns. In fig. 60 a bundle is shown enlarged. The columns were solid rods which cut like cheese. There was evidence of branching of the columns. The bundle was enclosed in an investment. The part of the bundle exhibited dotted was rather paler than the rest. A section of a bundle is shown in ng. 70. Some of the central cells have more granular contents than the others, in which the contents were of a clear yellow colour. The section was thick, and its minute

structure may not have been well made out. A small bundle measuring 4-5 mm. long, and about 4 mm. wide, is shown enlarged in fig. 73. It was amber-coloured, and covered with a thick fibrous wall, through which the columns projected. The muscle fibres were loosely attached to the outside of the ball. The projecting end of the column is covered with a skin of connective-tissue fibres (fig. 75). Air-bubbles have been noticed between the end of the column and its glove-like covering.

When a column is broken across nothing exudes from it. There is an outer homogeneous translucent rind and an inner granular core composed of small corpuscles. The rind seems to be tougher than the core. The striæ on the outside of the column tend to run longitudinally. Connective tissue seems to be bound up in the bundle of columns.

What appears to be the beginning of a column was observed between two muscle fibres (fig. 69). It measured ·57 by ·22 mm. The tuberculated bundle shown in fig. 56 measured 1·1 by ·55 mm. A number of vesicles or oil-drops were visible throughout it.

The columns are not the agents. They are the effect of the disease or injury, whatever it may be.

In one fish the columnar bodies, 2-5 mm. long and a little less in breadth, were dark red to the naked eye. When teazed out, the parts were of a pale amber colour.

Diseased Liver.*

The cod was of a fair size; it was thin, but otherwise quite normal.

The anterior part of the liver, measuring 5 inches (12 cm.) by $2\frac{3}{4}$ inches (7 cm.), was hard. One lobe at least had the light yellow colour of the normal liver. A section across the anterior portion is shown in fig. 78. The major portion of the section is occupied by two large cheesy masses, one of which (*b.*) is dark brown, the other (*dr.*) dark red, almost black in colour. The rest of the liver tissue (*t.*) is filled with amber-coloured tubers of various sizes and shapes. The tubers are attached to vessels. Nematodes were found among the tubers. The normally-coloured lobe of the liver is indicated at *lb.* The liver had a smell resembling that of seaweed.

The two cheesy masses are huge blood clots. When a part of the brown clot was put into water it gave off a milky fluid. On treating, first with ether and then with water, disorganised cells were made out. These I believe to be blood corpuscles. The dark red clot is stiffer in consistency. No white precipitate was given off in water, but the latter became greenish in colour. Blood corpuscles were made out. The brown clot is the older.

When the yellow lobe was cut a green fluid issued. This fluid is filled with oil globules, and contains little green bodies. The green bodies vary in size: they are very numerous: some are very minute (figs. 79, 80, 83, 88). One larger element (fig. 79) consisted of four ova surrounded by a greenish tissue, indicated in the figure by the dotted surface. It is shown surrounded by the oil globules (*og.*) of the liver fluid. The ovum (*ov.*) measured ·32 mm. in diameter. Among the smaller corpuscles in the fluid distinctive shades of green were observed. Thus the minute cell (fig. 83) was

* Presented by Mr. J. D. Sinclair, fish curer, Aberdeen.

of a dark green, while figs. 80 and 88 were of a lighter, more amber-coloured green. An egg-like body, ·1 mm. in diameter, obtained from the fluid, showed a capsule investing a ring of green corpuscles (*g.*), which surrounded a colourless central sphere (probably fig. 86). The lobe also contained tubers. The tubers are found attached to or in the walls of vessels (fig. 81). They are opaque amber generally, but when smaller than ·25 mm. by ·15 mm. they tend to become translucent, and show the cells inside. Under the microscope they are yellowish in colour. The tuber is enclosed in a connective tissue skin, which may be readily dissected off. In this skin is a large quantity of yellowish bodies and groups of green little eggs, similar to *z.*, fig. 92, and also of less size. Inside the tuber is much twisted and convoluted. When teazed up the tuber appears to be a mass of green cells.

The vessels attached to the mass of tubers are infected with little green bodies, which are attached thickly along them. Under the microscope these resolve themselves into two kinds of capsules. See fig. 92, which represents a portion of such a vessel. The two kinds of capsules are yellow, but one is opaque, *e.g. x, v, t*; the other translucent, *e.g., p, z, y.* The latter is the parasite. The vessel and the capsules are covered with connective tissue (*ct.*). The contents of the opaque capsules consist of little green corpuscles, which have a nucleus and granular contents (fig. 87). In the translucent capsules a nucleus may (*p*, fig. 92) or may not be visible (*y., ib.*). The latter capsule (*y.*) measured ·45 mm. in diameter, and appeared to be cellular. It is probably an advanced stage of the translucent capsules. A little capsule (*ov., ib.*) was colourless. The opaque capsules, to the naked eye, resemble the tuber in colour. They are probably the beginnings of tubers.

The parasite in an early condition is a translucent capsule, *e.g., ov.*, fig. 92. It absorbs green-coloured material (fig. 86) from the blood probably, and grows larger, becoming greenish-coloured. It derives its food from the blood corpuscles, I think, and the opaque capsules and tubers are, I consider, masses of disorganised blood corpuscles derived from the rupture of the wall of the little blood-vessel. It is possible that the blood corpuscles have also been digested by the parasite. The parasite is probably located in a capillary.

What was taken to be the gall-bladder was filled with an ink-black fluid. Under the microscope the fluid appeared as fatty drops combined with a finely-divided black pigment. Johnstone describes melanin in the liver of a skate (*Raia clavata*) which had a melanotic tumour on the outside of the body.

The normal liver of the cod is pink in colour. Under the microscope the liver fluid shows an enormous quantity of oil globules, with here and there amber-coloured channels. The latter are formed of blood from the crushed tissue.

Fig. 82 represents a section, approximately natural size, of another hard liver. Only a very little of the normal liver tissue remained at the circumference, *viz.*, at *l.* The rest is a cheesy solid, reddish-amber in colour, and very oily. In some cases a little strand of normal tissue is cut off in the cheesy mass, *e.g., st.* The central region (*ca.*) was filled with soft semi-fluid decayed matter. One nematode at least was observed coiled on the outside of the liver.

In a third case the liver, which was of a good yellow colour, had attached to one of its lobes by a narrow stalk a dark, hard mass, about 2 inches long. Here and there in the main liver tissue amber-coloured tubers could be seen. Some of these were long and narrow. The solid mass was found on cutting to be a dark red cheesy mass enclosed in a stout skin. This cheesy mass appeared to consist of blood corpuscles. The skin enclosing the clot contained amber-coloured patches, which were visible to the naked eye. One measured ·25 mm. by ·2 mm. Inside the green patch were one or two clear ova. They were colourless. There are little patches of granules, attached to which no ovum was made out. It may, however, have been present. The green patch is like a heap of green cells with granular contents. I think they are disorganised blood corpuscles. There appeared to be no inflammation of the parts adjoining the parasites.

What appeared to be a later stage of the diseased liver was also observed. The thick anterior part of the liver was reduced to a large cyst filled with a thick yellow greasy fluid. A lobe of the liver was still functioning. In the hind portion of this lobe tubers were observed. The diseased portion was bound to the mesentery and to the intestine. The parasite, whether it actually feeds on the blood corpuscles or not, causes hæmorrhage by rupturing or weakening the walls of the blood-vessels. I do not think this is a sporozoan. I think it may be the egg of a species of vermes.

The Myxosporidian *Myxobolus piriformis* is said to form cysts attached to the splenic artery of *Tinca tinca*.* Drew examined a red tumour attached by a narrow pedicel to the liver of a fish. Nodules of a similar nature projected from the surface of the liver, and were also present in the deep parts. He says there was an enormous hyperplasia of pancreatic tissue. An explanation was to consider it an adeno-carcinoma of the pancreas, when it would be possible to account for the superficial nodules as secondary metastases.

A large tumour† which had been apparently loosely attached inside the abdomen, probably to the liver, is seen in fig. 117. The cod was in good condition.

The tumour was coloured red at one end and greenish at the other. The former was soft, the latter hard. The soft end was filled with a red fluid. The tumour was divided up internally into regular chambers. The thick rind was greenish stained. The rind contained a greenish paste, in which gelatinous rods could be seen. No proper blood corpuscles were made out in the red fluid, but there were little irregular portions of amber-coloured tissue, which may have been destroyed corpuscles. Part of a section of the tumour is shown in fig. 119. The portion was filled with white They were dispersed right through the tissue, which is red. There are also solid nodules present. Each nodule was full of granules and corpuscles. An outer skin could be dissected off the nodule. This is probably the disease of the liver described above.

A normal liver of cod, when digested in a steam-heated boiler for the purpose of oil-extraction, usually falls away to a sort of muddy residue. But occasionally hardish lumps are found that resist this disintegration. They are of a friable, soapy or cheesy consistency. In a thin section dark granules are visible in a translucent matrix. This appears to have been a blood clot such as is described above.

* Gurley. † Presented by Mr. H. Cardno.

Diseased Kidney.

Tusk (*Brosmius brosme*).—The fish was in good condition. The outward form of the disease was a large irregular mass, measuring 3 inches (7·5 cm.) long by about 2 inches (5 cm.) wide by 1 inch (2·5 cm.) thick (fig. 44). It was dark coloured, and projected into the abdominal cavity on the left side of the ovary. It was covered with a thin skin (the skin of the kidney), which, through its blood supply, was reddish-coloured in parts. This tumour-like mass was simply a huge blood clot which had been formed by hæmorrhage, probably from the caudal vein. On the outside of the clot there was a whitish substance, a sort of dried pus.

The hind part of the kidney was diseased. The hæmal arch was filled with diseased tissue and round yellow bodies. The urinary bladder was large and normal. It was evident that none of the products of the disease had issued by the urethra.

The capsule of the tumour, *i.e.*, the skin of the kidney, is spotted all over with little brown oval bodies, which are also present in the mesentery.

The hind end of the kidney is a hard, nodulated, brown mass, in which there is a mat-like mass of soft fibrous tissue. This apparently consists of the vessels and urinary tubules, the tissue of the kidney having been destroyed. The vessels are covered with brown bodies (shown shaded in the figures, *sp.*, figs. 39, 46, 50). They are of various sizes. One measured ·2 by ·15 mm., while others were only ·1 mm. in diameter. They appear to be situated in little vessels. Some of the tubules end in swollen extremities, in which a coiled tube may be made out (*co.*, fig. 50). On one of the vessels a small glandular-looking swelling was observed (*g.*, fig. 39). In addition to the brown bodies, there are opaque yellow cysts in the diseased kidney. One measured 3 mm. in diameter (*c.*, fig. 50). It contained dry solid granular matter.

In the abdominal cavity, in the angle formed by the junction of the rectum with the ventral wall of the abdomen, there was in the mesentery a mass of cysts, some of which were 2 mm. long. They were amber-coloured, and had a glistening external coat. Certain of these cysts were also on the inside of the wall of the rectum. Some nematodes were observed alongside the cysts. The little brown or yellow bodies found in the kidney may not be the cause of the disease. The disease had evidently been long-standing. It had resulted in the decay of the tissue of the kidney, and in very extensive hæmorrhage, probably from the large vessels that lie close to the kidney.

Cod (*Gadus callarias*).—A disease similar to that found in the tusk was present in a codling. A large tumour which projected from the hind part of the roof of the abdominal cavity was a diseased and swollen part of the kidney. It was covered by the tough skin of the swim-bladder. Attached to the vessels of the kidney there were numbers of tubers (*x.*, fig. 49). The tuber was generally pear-shaped, and was united to the vessel by a narrow stalk. The tuber marked *x.* measured 1·7 by 1·5 mm. Most, if not all, of the kidney was infected. Instead of the brown bodies found in the tusk, there were here little white opaque bodies, which

measured about ·12 by ·1 mm. and ·15 mm. Except for the difference in colour, they looked just like the corresponding bodies in the tusk.

The skin of the swim-bladder next the kidney was inflamed, and a small quantity of green pus-like matter was present inside the swim-bladder.

Cod—Normal Kidney.—The normal kidney of the cod is a mass of thin-walled tubules (*tubuli uriniferi*) embedded in a dark red loose cellular tissue (fig. 157). The tubules are convoluted, and they contain corpuscles. They end, in some cases, in round swellings. A small spore-like body was found in a normal kidney (*sp.*, figs. 156 and 157). It measured ·07 mm. in diameter. No colour was made out in it. In another part of the kidney a cyst was found measuring about ·35 mm. in diameter.

Saithe (*Gadus virens*).—The kidney was replaced by a soft white mass, which, on washing in water, showed a ramifying fibrous body, the tubules of the kidney. The normal kidney shows the rounded, spirally-arranged tubules filled with corpuscles and embedded in the mass of red cells.

In one part at the exterior of the tumour, *i.e.*, where it was covered by the swim-bladder, a collection of brown bodies was visible. The semi-fluid white material of the tumour washed to a flocculent fibrous material. In some parts of the kidney, when the vessels were washed out, very fine hypha-like fibres were seen projecting from the vessels. A columnar-shaped body was observed among the diseased tissue.

None of the large blood-vessels seems to have been severed.

Saithe.—A large tumour on the anterior part of the kidney pressed out into the abdominal cavity, and also out between the lateral processes of the vertebræ into the muscles of the trunk. On cutting into the tumour, a thick white matter exuded.

The tumour had evidently been of long standing, for the spaces between the lateral processes of certain vertebræ had been increased in size by the deflection of the vertebral processes (fig. 118). The spaces marked *t.* had been occupied by the tumour. Some of the ribs had been displaced also. And in the case of one rib (v_4.), where the rib had been forced a considerable distance away from the lateral processes, a little intermediary bone (*b.*) had been formed. The ligaments are marked *lg.*

Another case of tumour of the kidney was found in a large saithe.* The tumour projected into the abdominal cavity on the right side of the swim-bladder (*tu.*, fig. 116). The diseased part of the kidney was white instead of being red. The diseased portion (tumour) ends and the normally-coloured kidney begins at a division between two vertebræ. Little cyst-like bodies are present in the tumour next the bone. In the same part are little white nodules and single cells coloured brown. There is a small quantity of brown pigment present also.

The tumour had grown out into the abdominal cavity, and also into the lateral trunk muscles. In the abdominal cavity it was covered with the peritoneum, and under that with the tough aponeurosis which covers the muscles connecting the ribs. This

* Presented by Mr. Paterson.

glistening white fibrous skin is thinned out over the big bulk of the tumour, permitting the red colour of the latter to shine through. The fibres run into the wall of the swim-bladder. In forcing its way into the abdominal cavity, the tumour had displaced some of the ribs.

The tumour had also pushed itself dorsally between the lateral processes of the vertebræ. Among the muscles it was enclosed in a tough fibrous envelope, to which it was loosely attached. The lateral trunk muscles had been displaced (fig. 122). One of the *a.* groups of muscles seemed to have disappeared, while several of the *b.* groups were distorted.

The lateral processes of the vertebræ have been deflected (fig. 120), and the ribs have been displaced from their attachment to them. Flat bony plates have developed to connect the separated bones, *e.g.*, *tv.* It is difficult to decide whether the rib marked (r_2.) or the lateral process had been broken or not. In this case there were four little bones joined together by ligature, connecting the rib to the vertebra. In this figure, parts of the tumour are indicated by (*h.*).

When cut open the tumour was found to be white inside. It is of a fibrous, spongy structure. It could be readily torn. An inside portion was of a pink colour. A section was cut by means of the freezing microtome (fig. 114). It showed a mass of irregular fibres, which showed a tendency here and there to run parallel to one another. There were small cells, some oval, others spindle-shaped. The tissue exhibited cavities, and also concentrated areas that resemble the section of a muscle bundle.

Cancerous Tissues in Fishes.

Several morbid tissues from fishes were sent to Dr. F. M. Milne, Clinical Pathologist, Royal Infirmary, Dundee. He very kindly cut sections of these specimens, and also very courteously gave me his opinion of their nature.

Two of the tumours he diagnosed as cancerous. Sections of them are shown in figs. 53 and 52. The former (fig. 53) was made from a tumour which was reported to have been found in the abdominal cavity of a catfish (*Anarrhichas lupus*). It appeared to be a colloid carcinoma. The nests of epithelial cells are shown. Vacuoles were observed in the nests, *e.g.*, *va.* They appeared to be filled with some coagulated material. *N'* and *n''* indicate the position of two other nests. An inflamed condition is seen at one end of the section, indicated by the closely-packed cells.

The second tumour (fig. 52) was found in the urinary bladder of a cod (*Gadus callarias*). The epithelium (*ep.*) is working its way down in the form of nests (*n.*) through the wall of the bladder. On the other side of the epithelium is a crystalline deposit (*cr.*), formed in consequence of the inflamed condition of the bladder wall. The epithelium cells are continued right into the crystalline deposit. This mass (*cr.*) appears to consist of enlarged and distorted epithelium tissue. It is a squamous Epithelioma.

Lymphostasis in Fishes.

Saithe (*Gadus virens*).—A very large tumour was found in the dorsal part of the pectoral region. It measured 5 inches (12 cm.)

by 3¼ inches (8 m.). It was bound to the aponeurosis by a fibrous tissue. Its main bulk was on the left side, but it extended through between the dorsal spines to the right side of the body. The tumour had not replaced the muscles; it had pushed them apart, or possibly prevented their full growrh. When cut across, the tumour was found to be white inside (fig. 152). In parts there was some black pigment in irregular specks. In some places it was sufficient in quantity to give the tissue a dark grey appearance. A white granular material exuded from the cut tumour. It was albuminous, and coagulated at once in water. The tissue is a delicate network of connective tissue enclosing lymph. An extensive system of small blood-vessels runs throughout the tissue. Under the microscope no oil was observed in the fluid.

The surface of the tumour was well supplied with blood-vessels. At the hilum, or part where the tumour was connected to the portion on the other side of the body, there was a small irregularly-shaped cavity filled with a reddish fluid (*bl. sp.*). There appeared to be a good deal of blood in it.

The tumour appears to be a lymph tumour. Elephantiasis is caused by the interruption of the lymphatics by Filaria. This seems to be an analogous disease, due to obstruction of the lymphatic vessel.

The muscles of this fish were also affected in a manner which is not uncommon in the species. The peripheral muscles become infiltrated with oil,* and the fibres swell up. This is analogous to the enriching of the muscles of the salmon with fat, but instead of the oil being distributed throughout all the muscles, it is here limited to a small region. The presence of the oil is detected by the change in the colour of the muscle-fibres. Instead of being translucent, they become of an amber colour. The affected muscles are distributed symmetrically round the trunk. Fig. 161 exhibits a section of the fish. The dotted region indicates the muscles filled with oil. There is normally a strip of so-called red muscle in the lateral-line region. But it may extend in through the trunk towards the vertebral column, and also spread dorsally and ventrally along next the skin. The oil is laid down first in the middle part of the fibre. Fig. 154 represents three myotomes seen from above, The shaded portion indicates the parts infiltrated with oil. A vertical section through the myotomes (fig. 153) shows how thin the affected layer may be, viz., *oil.* The affected fibres are much swollen (fig. 155). Part of a fibre is shown enlarged in fig. 160. The great increase in thickness due to the oil, which is visible in the form of longitudinal rows of corpuscles, is shown. The transverse striation is hidden; it is only visible at *x*. The oil corpuscles are probably located in the little compartments into which the fibrillæ are divided by the transverse striations. The fibrillæ within the muscle fibre appear to become infiltrated before the peripheral fibrillæ. Fig. 158 represents a fibre in which the fatty drops could be seen in the deep fibrillæ, while transverse striæ were visible in the surface fibrillæ. The extension of the region occupied by red muscle is no doubt due to some interference with the lymphatic

* I have throughout this part referred to the liquid with which the muscles are infiltrated as oil or fat. That is a description of its appearance. Its true nature was not made out.

system, which either arrests the abstraction of the lymph from the muscles, or causes it to be deposited in them.

The fatty infiltration is often more extensive in the tail region than it is anteriorly. It would seem to proceed from behind forwards.

A saithe in which the swim-bladder was partly filled with a greasy dark-red mass exhibited the extended fatty infiltration of the muscles. Posteriorly the bladder was completely filled up. The dark-red mass seemed to be mainly blood corpuscles. When it was diluted with water, minute fatty (?) granules and some long clear crystals were made out. This material occurred also in loculi between the coats of the swim-bladder. Its wall was papillose in one part. The fatty infiltration of the muscles was not so extensive as in the preceding case, and it was greater behind the second dorsal fin than in the pectoral region. In the pectoral region none of the red muscle extended to the vertebral column.

When a saithe which is much infected with the symmetrically-extended oil infiltration of the muscles is filletted the flesh may be found to be very prominently discoloured. This is observed sometimes in the tail region. The infected muscles are of a brown or dirty cream colour, and are readily distinguished among normal colourless muscles. They appear on the edge and along the middle of the fillet. When the fish is salted and dried the strips which traverse the trunk longitudinally are still prominent, and form a blemish. It is referred to as grease. In connection with one infected fish, little larvæ, like little diatomes, were observed.

A fish which showed the brown muscles in the tail region had a little mass of decayed matter next the hæmal spines. It probably indicated the disintegration of infected muscles.

A saithe had tumours just under the skin, near the bases of the caudal fin-rays. They were present in both dorsal and ventral sides. The flesh was diseased and broken up, but dry. None of the tumours seemed to be discharging through the skin.

Sporozoan Infection of Muscles.

An oval tumour* measuring about $3\frac{3}{4}$ inch (9·5 cm.) in greatest diameter was found in the trunk muscles of a catfish (*Anarrhichas lupus*). It was solid. On cutting into the tumour a whitish fluid exuded. The tumour was simply a mass of swollen muscle fibres. The swelling of the fibre was due to the presence inside it of a smaller or greater quantity of sporoblasts. The sporoblasts are apparently loosely arranged in the cavity formed by the separation of the fibrillæ (fig. 59A). The collection here represented (fig. 59A) measured about 1 mm. in diameter, and contained about 30 sporoblasts. Another oval collection was 1·2 mm. long. Sometimes the greater part of the length of the fibre is occupied by the sporoblasts. The fibres thus become tubes. The swollen fibres were either white or brown in colour. The former, the recently-infected fibres, were situated in the periphery of the tumour; the central region was occupied with brown fibres. A white fibre is shown in natural size in fig. 62. When such a fibre is teazed the

*Presented by Messrs. Sinclair & Robertson, Aberdeen.

fibrillæ are bathed in a clear plasma crowded with sporoblasts and free spores. The muscle fibres are quite normal. They have not been affected by the parasite. The latter does not feed on the muscle fibres. The sporoblasts all seem to be of one stage. They do not appear to be multiplying in the fibres. They are probably formed elsewhere in the body of the fish, and are deposited in the muscle fibres.

The spore is pear-shaped (fig. 59B). It is about ·005 mm. by ·003 mm. The spores are of two sizes. Hofer's drawing of the muscle bundle infected with *Myxobolus Pfeifferi* recalls the condition here described (fig. 59). The spore of that sporozoan, however, had two polar vesicles. A diagram of a section of the tumour is given in fig. 101. In the centre several myotomes are composed of brown fibres (*b.*), while at the periphery the fibres are white (*wh.*). Between the two a myotome consists of both brown and white fibres. The tumour is evidently extending at its periphery, and the normal fibres are being attacked. The brown fibres are dried up. They are about ·35 mm. broad and about 4 mm. long. They enclose the sporoblasts. When freed by teasing the spores seem to be similar to those got from the white fibres.

The tumour was mainly on one side of the dorsal region, but it extended through, by the space between the dorsal and vertebral spines, to the other side of the body. This small continuation had also a brown centre, showing that it had originated simultaneously with the larger portion. A smaller tumour occurred in the muscles a little apart from the large tumour.

No sporoblasts were found in the red fluid of the kidney. This is evidently the same disease which affected a *Zoarces viviparus* recorded in a previous paper (published 1911). This fish showed a number of tumours in the trunk muscles. A part of one of the tumours was sectioned by Dr. F. M. Milne, Dundee. Fig. 43 represents a small portion of one of the sections. The sporozoan (*spo.*) seen is occupying a position inside the muscle fibre (*m.*). It is evidently a collection of sporoblasts. Fig. 47 shows a portion still further magnified. *Spo.* represents a sporoblast, and *m.* the muscle fibrillæ.

The swollen muscle fibres described above recall the condition known as Miescher's tubes. According to Braun, Miescher and Hessling considered them to be pathological transformations of the muscles. Bertram described the Miescher's tubes found in the muscle of the pig, viz., *Sarcocystis miescheri*, R. Lankester [? *Sarcocystis miescheriana* (Kuhn)]. When fully developed it is between ·5 and 3 mm. in length, and ·4 mm in breadth. The chambers of the tube are filled with balls of sickle-shaped bodies. In their protoplasm there are dark "Körnchen," usually two vacuoles, and a nucleus. As soon as the Sarcocystis enters, a deposition of calcium salts may take place in the tubes and surrounding them.

As shown above, the muscle fibres may be swollen in two ways—first, by the collection in them of lymph, and, secondly, by the deposition in them of the sporoblasts of a sporozoan.

Linton describes a case of sporozoan infection of the muscle of the herring. Drew records a case where the muscles of the cod were invaded by a new species of Pleistophora. In the muscles there were diffuse pigmented areas of a brown colour. The muscle tissue in the

centre of the lesions was much degenerated. Small spherical vesicles, averaging about ·03 mm., were present in the interfibrillar tissue, or actually within the fibrils. Each contained a mass of protoplasm, dividing into spores, more than eight in number. The spores were oval in shape, and about ·003 mm. by ·0025 mm. No polar capsule was made out, but that was possibly due to imperfect preservation.

The same zoologist observed in the muscles of *Gadus luscus* cysts containing a gelatinous substance, and measuring 5 by 3 mm. The cysts contained pyriform spores, ·0035 by ·0025 mm. in size. A small vacuole was present at the broader end of the spore; a very minute body at the apex probably represented the polar vesicle. He gave this sporozoon the name *Glugea shiplei*.

A haddock had embedded in the muscles immediately subjacent to the lateral line a mass of brown, horny-looking substance. The substance was hard, and cut readily. Minute spores of some sporozoan, probably a species of *Glugea* were found. Drew regarded it as a case of vitreous degeneration of the muscles, due to a sporozoan infection.

The parasite described above as infecting the muscles of *Anarrhichas lupus* seems to be *Pleistophora hippoglossoides*, Bosanquet.

Tumours.

A number of fishes have been found that showed tumours in the muscles. In some cases the mass of infected muscles could be lifted out, leaving a clean cavity. The mass might be of a dry consistency. Other cases were found where the tumour had become purulent, and had eventually discharged through an opening it had made in the skin. The cavity had then been filled up with fibroid tissue. The infected myotomes are sharply defined from the normal muscles by the aponeurosis septa, and when the muscles break up and are discharged the aponeurosis grows into the space, filling it up with fibroid tissue. The origin of these diseased regions was not made out.

A codling had a swelling noticeable on the outside of the body. On removing the skin a large yellowish mass of columnar structure (hardened muscle) was found lying on both sides of the dorsal spines (fig. 169). The two masses were connected through three of the spaces between the dorsal spines. They measured 4 inches (10 cm.) by 1 inch (2·5 cm.) and 5½ in. (14 cm.) by ⅞ inch 2·2 cm.). The masses could be lifted out clean, leaving large cavities extending laterally from the skin to the vertebral column. The infection had taken place simultaneously on both sides of the body. The mass of muscle has become hardened and dried to some extent. Its fibres are whitish to the naked eye. Numbers of white bodies were observed in the skin bordering the cavity. A pair of similar masses were present in the ventral half of the body. They appear to have communicated between the vertebral spines.

In a saithe a tumour formed a deep cyst in the muscles. It was bounded by a tough fibrous capsule, which was well supplied with blood-vessels. The capsule belonged to the healthy tissue. The enclosed matter was quite separate from the capsule. It was in part columnar in structure, brownish in colour, and of a pasty, dryish consistency. Little white and brown bodies, ·5 and ·1 mm.

in size, were observed in the capsule. The white bodies contained an amorphous granular matter with some corpuscles.

A codling fillet containing a long tumour is shown in fig. 48. It is seen to be just a portion of the muscles. It indicates how the infection of the muscles may cut across the myotomes. The muscle layers were not broken; the shaded part was brown. The diseased part is not separated from the good. In another codling a tumour in the muscles could be felt from the outside. It was round, and of a reddish, dry, cheesy consistency. It extended right to the skin. It was composed of an amorphous mat-like material, granular in structure. No columnar structure was made out in the central region. The external surface of the tumour was soft; the outer rim was stratified and showed large cell-like cavities. The cavity in which the mass lay was bound by tough fibrous skin. This appears to be a mass of affected muscle being gradually broken down.

A fillet of a codling exhibited a series of cavities in the muscle (fig. 45). The cysts lie in the run of the muscles, but they sometimes divide up a bundle. They are extensive, irregular in shape, and, in some cases, extend inwards to the vertebral column. One or two of the cavities were clean holes, having a thick fibrous wall bounding them. Some were abscesses; they had no fascia nor fibrous wall, and the muscle was suffused with blood. The two sides of the cyst were connected with tissue suffused with blood. The cavity *x.* was of this character. It extended out to the skin. A considerable portion of the skin was without muscle, and from the outside of the fish appeared as a dark region. No perforation of the skin was made out. On cutting into one of the cysts, a reddish thin watery fluid came out. The muscle was consumed here to within 3 mm. of the skin. In another cyst the cavity extended to within 6 mm. of the skin.

I think that these cavities have been occupied by tumours of diseased muscle, which had decayed, and had been expelled by an opening in the skin. Another codling fillet had a large inflamed cavity stretching for a considerable distance along the skin.*

A saithe showed a condition of repair of similar cysts. Long red cavities were present in the fillet. One large red mass of tissue next the skin had a little bit of yellow matter in it. It had evidently opened to the exterior, and later on had healed up again. Some dead matter was still left in one or two small masses (*c.*) visible in the solid fibrous material (*f.*, fig. 164). They seemed to be connected by little passages to the exterior (*ap.*). The fibrous mass no doubt occupies the space formerly held by the diseased muscle. The aponeurosis will, as the pressure is relieved by the discharge of the decayed matter, tend to form the fibrid tissue. And it will do so until stayed by a return of pressure.

An example of the discharge of matter from the inflammation of the interior of the swim-bladder was observed. A small cod, captured at the Bay of Nigg, had in its shoulder a hole which penetrated to within a short distance of the lateral process of the vertebra. It was possible to trace the healed channel right to the side of the swim-bladder. The lips of the depression were a little papillose, but

* In a saithe similar cavities were, after preservation, green and red. In the diseased tissue spores, similar to those described above (*Pleistophora hippoglossoides*), were found in great quantity.

appeared to be quite healed. In the depression there was some gelatinous material enclosing what appeared to be a few sand grains and some crystals. The latter effervesced in dilute sulphuric acid (H_2SO_4). The ends of two ribs projected a little way through the skin.

The swim-bladder was normally distended with gas. On opening it, evidence of its having been diseased were apparent. The surface of the rete mirabile was enclosed in a thin skin, under which there was a layer of solidified yellow matter. The latter was gelatinous-like, not a true tissue. It interdigitated between the folds of the rete. A soft tuberculated mass was removed from between the folds. In it there were several white cysts. Similar opaque cysts were observed in the rete. The swim-bladder had been the seat of disease, which had been relieved by perforation of the wall of the body. The nerves on the inside of the wall of the abdomen were infested with trematode cysts.

The hole in the shoulder of the fish was in the place in which one would puncture a cod which had a swim-bladder abnormally distended. Sometimes a cod living in the aquarium at the Laboratory has its swim-bladder so distended that it floats helpless on the surface of the water. If the swim-bladder be punctured by a needle, and the gas allowed to escape, the fish is able to take its normal position in the water.

Gurley mentions the case of a *Gadus merlangus* affected with complete atrophy of the tail muscles, the tail being composed of nothing but skin and bone. Not the slightest trace of muscular tissue remained. The junction of the normal and atrophied tissue was abrupt, and was situated at the root of the tail. Woodhead described caseous tumours in the muscles of the Hake (*Merluccius vulgaris*).

Drouin de Bouville says that the disease Furunculosis salmonicida observed in *Trutta fario* consists in tumours which raise the skin at certain points on the body. At first the tumour encloses a yellowish-white caseous substance, which finally resolves itself into a blood-stained pus. The tumour eventually bursts, making ulcerous wounds, which give out a reddish discharge. He considers that the disease is of a bacterial origin, due to *Bacillus salmonicida*, Emmerich and Weibel.

Saithe.—A large tumour was present on both sides of the tail. It was firmly attached by gristle to the vertebral column. The hæmal arches of three vertebræ were broken. The disease appeared to have arisen within the hæmal arches. In the hæmal arches occupied by the tumour there was no sign of the caudal vein. Both anterior and posterior to the tumour the red caudal vein was visible. The end of the vein on the anterior side was filled with coagulated blood. The fish had been boiled before examination. This appeared to be a lymph tumour.

A large saithe had a tumour which projected from the head in a huge spherical mass.* The skin over the tumour was inflamed, and it seemed as if ready to open. Inside the tumour was a pasty mass, yellow and pink in colour. The matter was evil-smelling, and it showed here and there a little blood. It seems to have been a lymph tumour.

* Presented by Mr. G. Allan.

M'Intosh describes a myxoma in the plaice. It had a general resemblance to the tumour in the pectoral region of the saithe described above. Its principal bulk lay on the left side of the fish, but it had extended between the neural spines to the right side. Many of the neural spines were distinctly curved.

Angioma.

Cod.—A large pendulous tumour was firmly attached to the rete mirabile of the swim-bladder. It is shown in half-size in fig. 98. It was roughly ovid in shape, and measured 9·5 cm. by 6 cm. The inside layer of the wall of the swim-bladder was yellowish and soft. The outside skin of the tumour was somewhat hard, but it broke up and came off in shreds. The tumour could be readily torn. Fig. 97 represents a slice 2·5 cm. in thickness. The solid tissue is spongy: there are several large cavities.

The distal part contained coagulated blood: the proximal part is full of normally-coloured blood. Fig. 94 represents some of the blood corpuscles. It appears to be a blood-vessel tumour.

A portion of an angioma from a cod was sectioned by Dr. F. M. Milne. A small part of one of the sections is shown in fig. 54. *Cp.*, tumour on lemon sole, p. 22.

Tumours in the Peritoneum.

A Ling (*Molua molva*) which had been caught off the West Coast of Scotland had a large number of tumours on the wall of the abdomen (fig. 51). In the figure the dotted regions represent the tumours. They were thickly arranged along the swim-bladder. The tumour was a thickening of the peritoneum. It was white, fibrous, almost gristly in nature.

The abdominal cavity has a three-layered lining (fig. 121). The first is the peritoneum (*per.*), which is vascular. Next come two colourless thin fibrous layers (1*f.*, 2*f.*), which rest directly on the muscles. The peritoneum is attached equally all over to the fibrous layer. The two fibrous layers have strong attachments to the aponeurosis between the muscle segments; the lower layer is loosely attached to the muscles. The arrangement of the two fibrous layers is shown in fig. 123; the fibres run approximately at right-angles to one another.

The tumour is formed in the peritoneum (fig. 121), which has become fibrous tissue at the place. In the centre it has a sort of root (*rt.*, fig. 124), which penetrates the fibrous layers, to be in one case attached to the aponeurosis of the muscle. The separation of the fibres of the lower lavers to permit of the passage of the root is shown in fig. 125.

The tumour can be lifted right off the fibrous layers by severing the root, but one cannot separate the peritoneum from it without tearing the tumour (figs. 121 and 124). Some of the silvery-white pigment of the peritoneum can be seen on the under-surface of the tumour. The two fibrous layers were thickened into a cushion below this tumour. The root of the tumour may be the attachment of vessels. Some of the tumours have a brown-coloured central region, which can be dissected out as a separate solid. Might it indicate an earlier growth of the tumour? The small

tumours do not show the brown central region. In some cases the brown region sends an angle to near the surface: in others it is median.

Ling.—A tumour found inside a ling was about 1½ inch (4 cm.) in diameter. It had a thick wall, and contained an amber-coloured fluid. The wall on one side was thickened, and contained what appeared to be a quantity of coagulated blood.

Tumour on Skin of Porbeagle Shark (*Lamna cornubica*).

The fish was a male about 4 feet (120 cm.) in length. A large wart-like, but soft, excrescence projected from the side (*T.*, fig. 112). It was situated on the lateral line, and at about the middle of the length of the fish. The skin shows deep longitudinal grooves (*gr.*). The tumour is a flattened hemisphere about 1½ inch (4 cm.) in diameter (fig. 99), rising at its highest about ⅝ inch (1·5 cm.) from the surface of the side. It is not pigmented black as the skin of the fish is. The black pigment (*p.*) only extends to the edge of the tumour: the rest is without pigment.

The tumour is fibrous, and appears to be an excessive development of the derma. It has probably been formed in consequence of an injury to the skin. A portion of the pigmented skin had been destroyed, and the white tough, many-layered derma (*d.*) had been exposed. The derma layers have grown out into a highly-vascular fibrid pad. The upper layers run into the tumour: the bottom layers are separated and thickened a little. The blood supply was visible between the separated layers.

Drew describes a similar skin tumour on *Gadus merlangus*, and a fibro-sarcoma on a *Raia macrorhynchus*.

Tumour on a Plaice (*Pleuronectes platessa*).—The tumour, which was attached to the lower side of the fish by a sort of neck, was flattened (fig. 93). It rose about ⅜ inch (9 mm.) above the surface of the skin. A section through the fish and the tumour is shown in fig. 96. The tumour consisted of fibrous tissue. A cavity (*ca.*) extends a little way into the side of the fish. It had penetrated through the muscle (*m.*) as far as the yellow fatty tissue (*ft.*). Part of the muscle (*m.*) had been replaced by fibrous tissue. The muscles are shown striated. The tumour would appear to be a development of the aponeurosis.

Johnstone describes two similar tumours on the plaice (1909). Drew records a fibro-sarcoma on the same species.

Tumour on a Lemon Sole (*Pleuronectes microcephalus*).—The fish measured 14⅜ inches (36 cm.) in length, and was in good condition. The tumour was on the lower side (fig. 102). It was soft, and greenish in colour. It measured 2·5 by 2·1 cm. The skin covering the tumour contained scales, except over the central region. The scale-pits were further apart than on the normal regions.

A section of the tumour is shown in fig. 100. It consists of fibrous, spongy material, in which are several large cavities. From the latter much dark red fluid was pressed. The fluid appeared to be blood possibly disorganised. The fluid, when protected by a cover glass, had not coagulated after an interval of three hours, except at the edges. Some of the fluid exposed to the air had dried up. Fig. 95 represents some of the yellow corpuscles accompanied

by little refractile corpuscles. Much of the spongy fascia of the tumour was green: the rest was red in colour. Little masses of green granular substance enclosed in a thin skin were found inside the tumour.

The tumour rested on the lower muscles, and it had evidently replaced some of the superficial muscles. Fibres run from the skin, covering the central region into the tissue of the tumour.

Mesenteric Cyst from Skate (*Raia*).

A mesenteric cyst, shown in approximately natural size in fig. 103, was found in the abdomen of a skate. It was translucent, and contained a watery fluid. After preservation in formaline solution, a white flocculent precipitate was observed in the fluid, showing that a part of it had coagulated. The mesentery (*me.*) and the wall of the cyst was dotted all over with white tumours of various sizes, measuring from ·5 mm. to 8 mm. in diameter. They contained a white coagulated fluid. The mesentery was blotched with amber-colour here and there, the coloured patches varying from less than a millimeter up to an area of 5 mm. by 3 mm. in extent.

Tumour in Pharynx of a Salmon Caught in the Sea.

It is shown in natural size in fig. 139. It was found loose in the gill cavity after the fish had been killed by a blow on the head. Two of the gills were found to be damaged. There was a sinus in the free edge of the gill. It is not clear how the tumour was attached, but the connection was apparently a slender one. The tumour is lobulated, fibrous in structure, without any distinct lamina.

Bony Tumour.—Osteoma.

A rounded swelling was observed on the outside of a cod. It was due to a bony tumour attached to the vertebral column, and extending right to the skin. The tumour had displaced the trunk muscles. It is shown in half-size in *t.*, figs 131 and 135B. It was a tuberculated mass, and it was covered with fibrous fascia.

The tumour had pushed its way between the neural and hæmal spines, and had caused some of them to be deflected (fig. 135B). A small round portion of the tumour projected into the neural canal. It must have compressed the spinal cord.

A section of the vertebral column and the tumour is shown in natural size in fig. 140. It is seen that the tumour had arisen from one vertebra, viz., (*c*). Fig. 130 represents a longitudinal horizontal section of a normal vertebra. The tissue which forms the cancellous bone (*sr.*) is responsible for secreting the tumour. The control which adjacent parts normally exert had been in some way withdrawn, and the excessive bone formation resulted. The striation in the tumour is all radiate.

Ulcer on Plaice.

A disease which takes the form of a rodent ulcer is common on the upper and lower surfaces of plaice kept in confinement. It has been described by Anderson. He regarded it as caused by staphylococcus infection. The wound formed by the ulcer some-

times extends down through the muscles to the vertebral column, as in fig. 91, which represents a plaice 8 inches (20cm.) in length. The skin was in parts thrown into wrinkles (*wr.*). This would seem to indicate that the disease was extending below the integument. On the head the ulcer attacks the bones of the skull, and often destroys the eyes.

What appears to be the same disease was described by Johnstone. He ascribed the disease to a fungus which he found in the liver, kidney and mesenteries of the fish.

The diseased fishes, taken on one occasion from the pond at Bay of Nigg, in most cases exhibited the disease on the head. The head was inflamed and swollen, or partly eaten away. Some of the fish were blind. Their bodily condition was not bad. Some were very thin, others were plump. When the fish were opened the viscera appeared normal. The liver and kidney of one fish were examined with a view to finding if either organ was infected with parasites; no parasites were observed.

Riddell and Alexander have recently studied this disease. They consider it a bacterial disease due to one of three bacilli which they describe.

Some sections of one of the ulcers have been prepared by Dr. F. M. Milne, Dundee. Fig. 57 is a drawing made from one of the sections. The portion (*sk.*) represents the disorganised skin, in which the layers of the derma can be made out. The superficial muscle layer is indicated at *sm.*, while *m.* is a portion of the deeper muscle layer. On the outside of the skin a little black pigment is visible; and a small quantity is also to be made out on the outer side of the superficial muscle layer. The skin mass is covered with nucleated cells. The muscle bundles next the skin show vacuoles in them (fig. 55). All the muscles in the layer *m.* are affected. The layer is about three times as thick as the superficial muscle layer. A layer of connective tissue separates it from the still deeper muscles. The latter, with the exception of one or two bundles next the layer above, were normal (fig. 61) *i.e.*, without vacuoles. In the connective tissue laver a large vessel exhibited in its wall a layer of black or brown pigment.

The connected tissue between the vacuolated bundles is charged with blood corpuscles. The vessels are shrunken, and the corpuscles project from them (fig. 61).

There were large vessels in the superficial layer, *i.e.*, between the muscle bundles: they had blood corpuscles thickly dotted along them. The muscles themselves are evidently partly disorganised: vacuoles were seen in some of them.

A disease which had the form of rodent ulcers in the flesh of the Brown Trout (*Salvelinus fontinalis*) is described by Calkins. It was caused by Lympho-sporidium Truttæ. The sporozoites develop from a minute size to adult specimens (·025-·03 mm. in length) in the lymph spaces round the intestine. The adults pass into the muscle bundles about the intestine. Spore-forming individuals (·025-·03 mm.) are found in the lymph surrounding the various organs, and are quite numerous in the cavity of the gall-bladder and of the intestine. The spores measure ·002-·003 mm.

The cause of the disease in the Plaice is not yet elucidated. A combination of causes is no doubt to be reckoned with. A bruise

seems in many cases to cause an ulcer on the skin of a fish, but the possibility that the ulcers arise on uninjured areas is not excluded.

Cod—Pimpled Skin.

The fish* measured 3 feet 6 inches (105 cm.) in length. The skin and fins were covered with pimples. The pimples extended upon the clavicle inside the lip of the gill-chamber and all over the inside of the mouth. They were cysts either completely sunk in the derma or projecting from the lower surface of the derma into the connective tissue, separating it from the muscles. I did not see any cyst in the muscle.

The pimples measured up to 2 mm. in diameter. They are irregularly-shaped areas, reddish or purplish, showing through the white skin (fig. 132). Some of them showed little external scars, as if they had been punctured. On pressing one a little mass of thick stiff matter was forced out. Some have ulcer-like craters (*u.*) on them. The region appeared to be inflamed.

The spleen is remarkable, being spotted with dendritic white growths (fig. 129). The growths are shown of natural size in the drawing. The outside of the gut and liver is infected with great quantities of nematodes, most of which are coiled up.

Pinkish Flesh of a Codling.

The flesh of a codling was pinkish coloured. It was slightly stiffer to cut than the normally coloured fish.

Disease of the Eye—Pterygium.

One of the cod, which exhibited the deformity of the spinal curvature (p. 35), had a diseased eye. It was a white opaque patch (*w.*) over part of the pupil (fig. 170). It was in parts coloured red by blood-vessels that ran over it from the bulbar conjunctiva. The pterygium is a changed part of the cornea. Blood-vessels can also be seen in a part of the conjunctiva that is still translucent, viz., at *tr.* The eyeball was spotted with yellowish blotches.

The normal cornea can be dissected into two layers, both of which are translucent. The inner layer is tough, gristly. Fig. 172 shows a section through the cataract. One half, the outer, of the cornea is diseased (*d.*), while the inner (*n.*) is translucent.

Perforation of the Gut.

Foreign Bodies in the Abdominal Cavity of Fishes.

A number of cases where some of the food of the fish had escaped from the alimentary tract into the abdominal cavity, to become encysted there, were recorded in a previous paper. In the majority of instances the food was sandeels (*Ammodytes*). It was difficult to understand how these fishes had managed to perforate the wall of the stomach or gut. Barrett had suggested that the sandeel had

* Presented by Mr. Rose.

forced its way into a pyloric cæcum, and had then either ruptured the blind end of the same, or had broken the cæcum off from its attachment to the gut.

A specimen (? Saithe) showed one way in which the gut may be perforated. That is by the agency of a sharp bone. Fig. 127 represents the condition of the organ. The gut had been perforated at g^1 by a parasphenoid bone, 1·6 cm., which remained stuck in the wound (fig. 145). The liver had been injured close to the aperture. A portion had become decayed (*dl.*, fig. 127). Scales of fishes were found at this part, indicating that food had escaped from the gut. The parts of the liver marked (*l.*) were normal. The original skin of the liver had hardened. A new skin—a growth of the mesentery—covered the liver, part of the ovary, and evidently the wounded part of the gut. It was not attached to the liver; a space (*ca.*) separated it from that organ (fig. 150).

An enlarged view is given in fig. 145. The bone had all but cut the gut right across. The latter still held together on the side next the liver. The lips of the hole had become thickened, and so had the wall of the gut for about 1 inch (2·5 cm.) on either side. The thickened lip (*t.l.*) pressed down on the bone and fitted on to the broad smooth edge (*e.*), closing the aperture. The skin (*sk.*) covered up the part. If this bone had not been arrested in the wound the wall of the gut would probably have healed up without leaving any scar.

A liver of a cod had attached to it a sharp curved bone which was evidently the first ventral interspinous bone of a species of flatfish. It did not belong to *Pleuronectes platessa*. The sharp strong point of this bone had probably pierced the gut or stomach wall.

In another case two bones were found on the abdominal wall of a cod. One was a large sickle-shaped bone, the first ventral interspinous bone of a plaice. Its sharp point was embedded in the muscles for fully half-an-inch. The part had been inflamed. The second bone was the branchiostegal bone of a fish.

I think that in both these cases the bones had been the agents which perforated the gut.

In the abdomen of *Sparus centrodontus*, a mummified fish resembling a sandeel, was found. No lesion was visible in the alimentary tract. The pylonic cæca are wide tubes, but they did not appear to be any weaker than the gut.

In a large cod, which was in good condition, the mesentery of the gut was fused to the bottom of the abdominal cavity. On the wall of the abdomen there were two portions of hardened food. One portion of the latter seemed to be part of the limb of a decapod crustacean. No trace of lesion was detected in the stomach or gut.

Damaged Liver of Saithe.—The posterior end of the liver was adhering to the swim-bladder. An intermediate portion of the liver was very oily. The swim-bladder was collapsed. On it there were otoliths resembling those of the whiting (*Gadus merlangus*), Their presence indicated that the alimentary canal had been ruptured at some time.

Ruptured Ovary of Cod (August).—The fish was 2 feet 8 inches (80 cm.) long. Its abdominal organs were coated with ova, which had stuck to them and marked them with a honeycomb appearance. The mesentery had grown greatly in thickness. The eggs were

shrivelled, and measured 1·25-1·37 mm. in diameter. Some were still spherical. There was no signs of development in the ova. The ovary was small, and when it reached me it was ruptured. At first it appeared to be a case where the stomach or the gut had been ruptured and had permitted eggs which had been eaten by the fish to pass out into the abdominal cavity. The ovary had some old unspawned eggs in it: one measured 1·3 mm. in diameter. The ovarian ridges had very small immature eggs. This was evidently a case where the ripe ovary had been ruptured, and the eggs had escaped into the abdominal cavity. The stomach of the fish contained two or three small sandeels.

Bone in the Stomach of a Salmon.—A salmon was found dead in fresh water about 12 miles up from the mouth of the Helmsdale. A bone was found sticking in the wall of the stomach, which had been perforated. Great inflammation had been set up, apparently causing the death of the fish. Mr. W. L. Calderwood kindly forwarded the bone to me. It is evidently part of the lower jaw of a fish. It is shown in natural size in fig. 148. The bone is a dentary, and it has been broken. It is membranous and remarkably thin. It resembles the dentary of a herring, but it is longer and more fragile. The teeth are very small for the size of the jaw. The upper ramus of the bone is longer than the lower. While it resembles a little the corresponding bone of a pike, the teeth are too small for that species. I have not been able to determine the species to which it belongs.

Bone in the Lip of a Skate.—A serrated spine, apparently one of the spines of the dorsal fin of a Gurnard (*Trigla*), was found broken off and embedded in the side of a skate's mouth.

Discoloured Flesh of Salmon.

Mr. J. Hector, salmon merchant, Aberdeen, kindly sent to the Laboratory, on April 24, 1912, a salmon which had, on cutting, been found to be discoloured in the flesh. The fish weighed 17 lb. It had been gutted, but as it had a fairly prominent kype on the lower jaw it was judged to be a male. The fish was in excellent condition. From the middle of the length of the abdomen backwards the flesh was in increasing extent coloured red instead of pink. Fig. 107 shows the extent of the red colouration (*r.*) at about the middle of the abdomen. In front of the first dorsal fin the red region extended well on both sides of the vertebral column (fig. 108). A little behind the pelvic fins a somewhat similar condition was found. The muscles in the wall of the abdomen were brownish. At the beginning of the anal fin the whole section was dark red.

The red colouration of the flesh is consequent on bruises received before death. In this case there was no recently-made bruise visible. The fatty fin, however, was deformed (fig. 110). It was hollow, the inside tissue had disappeared, and two apertures (*ap.*) gave access to the cavity. On the ventral edge of the body, just behind the anal fin, there was a wound which was almost quite healed. The anal fin is inflamed a little; the membrane is red-coloured. I could not find that in either of the two former cases the wound had penetrated deeper than the skin. The wound in the fatty fin was discharging a little yet. I examined some of the

matter scraped off the inside of the cavity. I did not find any very definite indications of fungus, but a few fine hypha-like filaments were present.

On dissecting the fish and separating the muscles along the dorsal spines of the vertebræ, three blood-extravasations were found below the fatty fin (fig. 105). Further forward, and immediately behind the first dorsal fin, I found, just under the skin on the right side, a small purple-coloured region. It appeared to have been an old sore. The skin over it was quite normal. In the same region a dark red patch was observed in the muscles above the dorsal spines. When the dark red muscle fibres were examined under the microscope the capillaries were found to be distended with blood. Here and there extensive groups of corpuscles indicated the rupture of capillaries. In the two regions, then, the blood-vessels crossing the dorsal spines had been ruptured. No bones appeared to have been broken, however. The dark-red colouration was very small in extent. The flesh generally was a light red, except in the anterior parts, where it was of the normal pink colour. The pink muscle fibre and the red muscle fibre were examined under the microscope. On teazing out a piece of pink muscle one gradually lost the pink colour as the pieces became smaller. The pink sheen could still be made out with the naked eye in a piece of muscle 1 mm. in thickness. The separate fibres were colourless. Only here and there among the fibres was a portion of a capillary to be seen. It was made out by the fact that it enclosed a few blood corpuscles. When the corpuscles are absent, the vessel is invisible. A few corpuscles were made out: they were probably liberated when the fibres were separated. Transverse striæ may be seen in the fibre. In the fibrillæ are rows of little fat globules (fig. 111). The fibrils have sheaths, and the oil globules are inside the sheaths. They may be in the compartments into which the striæ appear to divide the fibril.

Now, the fibres of the bright red muscle are supplied with very many capillaries (*ca.*, fig. 106) filled with blood corpuscles. This excessive quantity of blood gives, with the normal pink, a red colour to the flesh. Under a high-power the corpuscles are yellowish-amber or greenish in colour. The capillary appears to end blindly in places: that is due to the absence of blood corpuscles at the part and the probable contraction of the vessel. Many of the capillaries have probably been ruptured.

The effect of the injuries has been to cause the escape at certain points of blood from vessels alongside the dorsal spines of the vertebræ, also the suffusion with blood of the muscles in the posterior half of the fish generally. How the latter has happened is difficult to follow, unless it has resulted from the former. The rupture of some veins may have interrupted the return of the blood from the capillaries, which therefore remain distended.

The injuries have not probably been recently done. They seem to have been due to bites by a salmon. The aggressor had seized the body of the other at the region of the fatty fin, and compressed it dorso-ventrally. This would cause the rupture of the vessels beside the dorsal spines. The sharp teeth of the salmon would wound the fatty fin, and also the edge of the body behind the anal fin. The injury in the region behind the first dorsal fin probably resulted from a bite also. Owing to the fact that the wounds were

healed, and the fish was in a very fat condition, the injuries must have been caused some months, at least, previously. The effect of an external injury would then appear to remain a long time in the muscles. The injury had been done, I believe, in fresh water. I therefore examined a scale in order to find the "spawning-mark" described by Johnstone. I made out no such mark on the scale. The fish was quite healthy, so far as I could judge. I examined several of the nerves on the inside of the abdominal wall, but found no trematode cysts.

A cod showed a number of red regions scattered through the whole of its flesh. They measured in greatest size about 6 mm. The bloodvessels between the muscle fibres were swollen and flushed with blood, and they gave the patch a dark-red colouration. There were many red areas along the ribs. This condition is probably due to mechanical injury before death.

An interesting question is concerned with the cause of the difference in colour between the muscles in different parts of the fish. Many fishes have brown or red muscles along the side of the body, near the lateral line, while the main mass of the muscles is pale or colourless. Stirling says that in the haddock and whiting the red muscle fibres, seen in a cross section made at the lateral line, are smaller in diameter than the pale muscle fibres. "The red muscle shows in the substance of the sarcous matter several rows of bright refractive fatty granules, which in some fibres assume a more or less longitudinal course." He further remarks that the red muscle fibres present all the appearance of a muscle in a state of fatty infiltration, or fatty degeneration.

Mahalanobis, in discussing the fat in the flesh of the salmon, says that the muscle is not correctly described as undergoing fatty degeneration. The condition should be described as interfibrillary infiltration of fat. . . In all probability the muscle cells absorbed fat and stored it between the fibrils. . . The loss of transverse striation is partly due to the interfibrillary granules of fat.

If a piece of the brown muscle from the salmon be teazed out, the fibres are found to have much more oil than those of the pink muscle. There is also a greater collection of oil globules between the fibres of the former. When a piece of the brown muscle is teazed out it is bathed in a copious bath of the oil set free: the fibres separate very readily. Under the microscope this fibre is much more opaque than that of the pink muscle. Fig. 109 represents a red fibre as seen with Obj. Oil immersion 2 mm. Oc. 4. The fibrillæ are crowded with comparatively large oil globules, which evidently distend their sheaths. The fibrillæ, in consequence of the closely-packed globules and their swollen condition, are more distinct than in the pink muscle. The transverse striæ were not made out in the brown muscle fibre.

The pink colouration of the flesh of the salmon would appear to depend on the quantity of oil in the muscle fibre, and perhaps also on the structure of the fibre. The oil itself is colourless. I do not consider that the pink colouration of the muscle is due to pigment. Newbigin, however, extracted two pigments, pink and yellow respectively, from the muscles of the salmon. She considered the pink colour of the flesh to be due to the presence of coloured fat.

Worm Parasites of Fishes.

Trichina *sp.*—A trichina-like parasite, resembling that which occurs in the muscles of the Cod,* was observed in the muscle of *Sebastes marinus*. I have found the muscles of *Conger vulgaris* also infected with Trichina.

An experiment to test the resistance of the Trichina in a fish fillet was made by Mr. Erlandson. The fillet was subjected to strong salt solution and to smoking for double the usual time. Thereafter two live worms and two dead worms were extracted. Nine days later a number of worms were taken out, but all were apparently dead.

Tetrarhynchus megacephalus (Rud.).—A young stage of this worm occurs frequently in Saithe caught near Iceland. It is shown in natural size, after preservation, in fig. 133. Thirteen† examples have been found in one fish. They were located between the peritoneum and the wall of the abdomen. One was found inside the swim-bladder. I have observed this form inside the mesentery. Lönnberg describes under the name *Tetrarhynchus linguatula* (P. v. Beneden) the same young parasite. It was attached to the ventrical wall of the abdomen of a saithe. It measured 27 mm. in length, and 6 mm. in width. A similar form has been recently described by Johnstone under the name *Cœnomorphus linguatula* (Van Beneden). The specimens were adhering to the liver of a Saithe captured near St. Kilda. The author states that *Tetrarhynchus megacephalus* (Rud.) may be the final form of *Cœnomorphus*.

Van Beneden described a large example of this species which he had found in the gut of a Greenland Shark (*Scimnus glacialis*). Dr. T. Scott, who kindly drew my attention to Van Beneden's paper, has recorded an example 18 inches long from the intestine of the same fish.

Tetrarhynchus erinaceus (Van Beneden).—Cysts of this worm were found in the muscles of a Sebastes marinus. They were brown coloured. The contained larva was white. The ruptured cyst shown in A., fig. 37, measured 1·3 cm. in length. The pear-shaped larva (A. and B.) was about 5 mm. in length and 2·5 mm. in greatest width. Other cysts measured ·35 by ·1 mm. and ·2 by about ·05 mm.

Several of the larvæ extracted from the cysts were put into fresh water. They became active at once, and began to extend their bodies. One eventually everted at the broad extremity a long process bearing four toothed horns (fig. 37c). A sketch of some of the hooks that adorned the horn is given in fig. *ib.* d. Another larva everted from the posterior end a comb-like process.

This is evidently the young form of *Tetrarhynchus erinaceus* (Van Beneden). Scott found the species in small cysts in the walls of the stomach and pyloric cæca of cod and saithe. Johnstone has recently given a detailed description of the adult and larva.

Echinorhynchus acus (Rud.).—A specimen of this species (fig. 134) was sent to the Laboratory attached to the peritoneum of a fish. The latter was probably a saithe. Scott found the parasite in the intestine of the saithe.

* Williamson : "Eggs of Angler, etc." † Presented by Mr. H. Cardno.

Deformed Fishes.

Humpty Cod.—Hump-backed cod are not uncommon. They are found among those captured in the North Sea and at Farœ: they are said not to occur among Iceland fish. It has also been maintained that humpty cod are more common in the catches of the inshore boats: they are very rarely got by the deep-water boats. Some were, however, got 50 miles off Aberdeen.

The cod is shortened. While the anterior and posterior portions of the body are normal, the middle part of the trunk has increased in dorso-ventral extent and decreased in length (fig. 128). The body narrows abruptly behind the abdomen (figs. 104 and 128). The abnormality occurs in the vertebral column. The humpty fish is bilaterally symmetrical.

When the vertebral column of such a fish is cleaned the intermediate vertebræ are found to be individually shortened and also to be fused together in groups. The column is thickened there, and when the fish is being split this part catches the knife. The fish represented in fig. 128 measured 44 cm. in length. It had been gutted. The abdominal cavity extended posteriorly as far as the first third of the first anal fin. Little white balls, resembling the cysts in the eye of *Gadus esmarki* were present in the sclerotic. Concretions were found at different parts of the skull.

The vertebral column is shown in fig. 149. It consisted of 52 vertebræ. The following analysis divides the vertebræ into normal and abnormal, and the latter into independent and fused vertebræ.

Veatebræ, 1-5 normal.
,, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, abnormal, independent.
,, 15, 16, 17, abnormal, fused.
,, 18, 19, ,, ,, Vertebra 19 bears the first hæmal arch.
,, 20, 21, ,, ,,
,, 22, ,, independent.
,, 23-29, ,, fused.
,, 30, 31, slightly abnormal, independent.
,, 32, 33, 34, ,, ,, fused, broadened.
,, 35, 36, normal.
,, 37, 38, 39, slightly abnormal, fused, broadened. The drawing wrongly shows Vertebræ 37-40 fused.
,, 40, 41. ,, ,, fused. The drawing wrongly shows Vertebræ 41 and 42 fused.
,, 42-52 normal.

Vertebræ 6 and 7 are slightly abnormal (fig. 146). They are shorter and broader than Nos. 4 and 5. The joint between these vertebræ is open at the edges. The anterior end of No. 7 is seen in fig. 141. The cone (*cn.*) shows the extent of the attachment to the adjacent vertebra. Its abnormally small size is seen when it is compared with the large normal cone of the 5th vertebra (fig. 142). In the normal vertebra each end is a deep hollow cone, extending across the whole breath of the vertebra (*cn.* fig. 151). The adjacent vertebræ are bound together round the rims. The double cone in the joint is filled with a clear colourless jelly material.

The cone in the end of the abnormal vertebræ gradually becomes smaller and the vertebræ thinner as one proceeds along the column.

The 14th vertebræ is represented in fig. 138. A little bony boss is present above and below the cone. A side view of vertebra 22 is shown in fig. 144. The cones between the groups 15-17 and 18-19 are small, not exceeding 2 mm. in diameter. The former group, in which the lines of fused and individual vertebræ could not be traced, was cut longitudinally (fig. 143). A little double cone is seen to be present between the component vertebræ. The vertebræ had been normal up to a certain stage in the life of the fish, viz., when the vertebra was between 2 and 3 mm. in diameter, *i.e.*, the size of the double cone. Thereafter a diseased condition of the joints had supervened. The vertebra had grown no more in length. All its increase had been in breadth. The ends of the vertebræ had adhered. The line of fusion can be traced in the section, and along it there are some little spaces. The size of the cone on the end of the vertebra indicates the period when the disease attacked the vertebra. It evidently attacked the median vertebræ first, thereafter, proceeding towards each extremity. In this way some of the vertebræ would be attacked much later than others. Vertebræ 37 and 38 appeared to have fused recently.

At first all the vertebræ would be movable. Later on, as the normal vertebræ grew in length, it is probable that the joints between the thin vertebræ would not all he moved in the action of swimming. Some of them would probably tend to fuse. The abnormal vertebræ that remained movable have irregular, roughened ends (*e.g.*, fig. 136). In this case half of the cone only is present, and the hilum is hardly traceable. The thin vertebra may be concave on one side and convex on the other (fig. 144). In the unhealthy joints which are still movable there was a fleshy-like tissue instead of the jelly mass present in the normal joint.

The shortened vertebræ usually have their dorsal and hæmal spines connected by a bony plate.

The neural and hæmal spines of vertebræ 34 and 35 have been broken and mended.

Between some of the abnormal vertebræ there were little tumour-like swellings about 3 mm. in diameter. One tumour that issued from between vertebræ 17 and 18 (*tu.*, fig. 136) was brown in colour. It had formed a depression in the bone. Tumours were present in the neural canal attached, apparently, to the neural sheath, which seemed to be thickened. The spinal cord did not seem to be affected.

I examined the joints of a humpty cod in the fresh condition. There was only a very small cone-mass of jelly, brownish in colour. Under the microscope some little brown or opaque white bodies, apparently stalked, were observed. The bodies had thick walls (figs. 58 and 66). There was some other amber-coloured tissue exhibiting a great quantity of minute corpuscles.

Two hump-backed cod were mature. A male measuring $34\frac{1}{2}$ inches (87 cm.) in length was ripe: a female $21\frac{3}{4}$ inches (54 cm.) was spent. The abnormal portion in both was short. In the former it was over the kidney. This fish had a slight spinal curvature also. Part of the kidney was much broken up. I found therein colourless cysts varying in size from ·07 mm. in diameter to 1·4 mm. in length. They in some cases showed a single chamber, in others several chambers. Some of the cysts enclosed a vermiform

body (fig. 38). The jelly material between certain of the affected vertebræ was small in quantity and suffused with blood. The brown-coloured muscle of the lateral line region extends inwards to the backbone. In the hind end of the swim-bladder a quantity of yellow matter had been deposited.

In the female the hump part extended posterior to the kidney region. It began at the end of the kidney.

The kidney contained many white cysts, which were visible to the naked eye. The cysts had thick capsules, and in some cases were attached to fibrous material. They were circular or oval. The cyst shown in fig. 40 measured about ·32 mm. in length. A spherical cyst was ·15 in diameter. A small cyst (fig. 41) was surrounded by a green mass of small cells which resembled blood corpuscles. The apparent nuclei in the cysts are vacuoles filled with large clear corpuscles, in which are scattered little oil drops. The cysts may be found in a group (*e.g.*, fig. 42). They were surrounded by a narrow green-coloured rim. One showed a hernia, which may have been caused artificially. Several encysted *Gasterostomum gracilescens* were present in the spinal canal.

Auerbach describes *Myxobolus æglefini*, parasitic in the bone-cavities, in the periost, or in the connective tissue between single bones of the head of *Gadus æglefinus*. The spores are round to elliptical. Their length reaches about 10·8-11·7 μ, breadth 9·9-10·4 μ, thickness 7·2-9 μ. Two polar capsules are present in the spore.

The following is the analysis of the vertebræ of another humpty cod:—

Vertebræ	1-9,	normal.
,,	10-13,	abnormal, fused.
,,	14-17,	,, ,,
,,	18-21,	,, ,,
,,	22-24,	,, ,,
,,	25, 26,	,, ,,
,,	27, 28, 29,	normal.
,,	30-32,	abnormal, fused.
,,	33, 34,	,, ,,
,,	35-50,	normal.

Total number of Vertebræ, 50.

Dyce discussed the identity of the fish known as the speckled cod or lord-fish (*Morrhua punctata*). He showed that it was simply a cod which had become deformed in consequence of disease of the spine. It was what has been described above as a humpty cod. He had observed a similar deformity in the haddock (*Gadus æglefinus*). He gave drawings of two deformed vertebral columns of the cod and of three of the haddock. He remarked that the diseased portions are neither uniform in extent nor in situation. In some the thickened part is near the tail, while in others it is nearer the head. Occasionally two diseased portions are met with, having a few healthy vertebræ intervening. The transverses of the diseased vertebræ are stronger, longer, and generally undulated, presenting much the appearance of broken bones badly united. In one of the backbones of the haddock the diseased part was confined to the caudal extremity.

He said that he had constantly met with examples, oftener in some years than in others, but never in a large full-grown cod. It was far more common in the haddock, and often in fishes 18 or 20

inches long, and the fishers asserted that they occasionally met with it in the coal-fish (*Gadus virens*). He suggested as the possible cause, debility in the vascular system, in consequence of which the bones lose their phosphate of lime, become soft and spongy, then absorbed, and the joints become thickened and enlarged—in short, rickety, as found in the human subject.

Several examples of Humpty haddocks are preserved in the Laboratory.

Hump-backed Hake* (*Merluccius vulgaris*). A hump-backed hake measuring 24 inches (60 cm.) in length had the hump in the post-anal body. It extended close up to the root of the tail. The tail was normal. There was a series of little tumours, measuring up to 7 mm. across, between several of the vertebræ of the abnormal part. They had a definite cyst wall, and they were located mostly between the vertebral spines, dorsal or ventral. The contents consisted of dried material, in which I was able to make out no definite structure.

Cobbold recorded a hunch-back trout. He said: "We have here an extreme abrogation of the spinal column resulting from the coalescense of numerous vertebral centra."

Hyrtl stated that "the number of coalesced vertebræ is from 2 to 6, and this synostosis takes place more frequently in the tail than in the trunk of the fish. The diminution of the flexibility of the fish, due to the abolition of the inter-vertebral articulation, is obviated by the fact that the confluent vertebræ are not longer than one and a slight fraction of a non-coalesced one. The synostosis is not due to pathological deformities, there being no callosity present to suggest a mechanical injury, and no deposits of calcareous matter to induce us to regard the synostosis as a senile metamorphosis. The inter-vertebral foramina appear never to be perfectly obliterated, although they are exceedingly diminished in size. The synostosis is, without doubt, of a physiological character, and it must take place early in life, when the length of the bodies of the vertebræ is so short that 2, 3, 4, or 5 such lengths are equal to the length of a single vertebra of a fully-grown-up individual. When the increase in length is stopped the increase in circumference continues, as in non-synostosed vertebral bodies."

Howes drew attention to the fact that Hyrtl later described a case in the cod, in which 6 co-ossified vertebræ occupied a greater area than the two which preceded them. The author regarded the deformity as congenital.

Ritchie records a hump-backed trout. He considered that the malformation did not arise from the fusion of little groups of vertebræ. He regarded each group as a true centrum having an abnormal number of spines. If this condition actually occurs it is not always the case, as the longitudinal section of the fused mass has shown the different centra distinctly marked off.

Spinal Curvature.

This abnormality is comparatively common in the cod. A number of instances of its occurrence in large cod have come under

* Presented by Mr Napier, Aberdeen.

my notice. Storrow records it in a codling $9\frac{7}{8}$ inches (25 cm.) in length.

The deformity does not appear to affect the general health of the fish, for in three cod, a male and two females, measuring 76-90 cm., the reproductive organs were ripening normally. The body of the fish is malformed externally (fig. 162). In this drawing the tail is shown in a horizontal position, but it could be kept vertical. The trunk shows bends to the right and left: it is bilaterally asymmetrical. The fish, however, tends to keep a general straightness, as is seen by the run of the unpaired fins. The abdominal cavity in the fish (fig. 162) showed a bend to the left and then to the right. The swim-bladder followed the curves. The vertebral column shows a much greater distortion than the trunk. Fig. 168 represents the line taken by the vertebræ of one of the fishes, seen from above, while in fig. 167 a side view of the same is given.

Part of the vertebral column of one fish (fig. 162) appears in dorsal view (fig. 159). At the part near the first hæmal arch (1H) the vertebræ were lying nearly on their sides. The column began to bend to the right at the 11th vertebra. The 12th went to the right. The 13th to 17th turned to the left. The 18th vertebra began the return to the right. Vertebra 19 to 23 went to the right. Vertebra No. 24 was normal. The total number of vertebræ was 52. The neural spines have been broken or strongly bent: some of them show swellings which indicate repaired fractures.

In the bent portion the vertebræ are asymmetrical (*cp.* fig. 166).

A drawing of part of the vertebral column of another deformed cod is given in fig. 163. The neural spines have been much injured; they have been repaired in various ways. The neural arches of vertebræ 16 and 17 have been broken on the left side only. The hæmal arches of vertebræ 19, 22, and 24 were broken on the right side only. This would indicate a torsion of the fish.

A third large cod showed a similar deformity. In addition to the fracture and bending of the spines and arches, one vertebra (No. 29) was broken right across (fig. 171). The neural and hæmal arches were also fractured. The injury had not been repaired: the fracture remained as a movable joint. In this fish there was an indication in some of the joints of disease similar to what occurs in the humpty cod.

A well-marked case of spinal curvature in the haddock is preserved in the Laboratory. A horse-mackerel (*Caranx trachurus*) also exhibited a like deformity.

Is the curvature the cause of the fracture of the spines and vertebra; or were the injuries to the backbone the result of external violence to the fish?

Spinal curvature may occur in larvæ, as Day pointed out in reference to salmon. Fig. 165 shows a sea trout (*Salmo trutta*) which was hatched at the Laboratory, and which showed two curves (*b.* and b^1.) in the notochord.

It is quite possible that in the cod the deformity had occurred in a very young stage, and the curvature had probably so distributed the stresses when the fish was swimming actively as to cause the fracture of the vertebral spines. The vertebral spines are bent so as to bring their tips, which support the fins, approximately into the straight line of the normal parts of the fish.

Barrington made mention of crooked perch and trout in Wales. Howes said that in the curvature of the spine there was no co-ossification of the vertebræ, but the neural spines of certain of the vertebræ bore synostotic enlargements indicative of preceding fracture. He regarded the synostoses, compression and sinuation, as congenital, but that the muscular rather than the skeletal system had been at fault, was largely proved by the fact that there was no marked falling-off in either the bulk or the density of the latter where disturbances occurred, and the most logical determining cause seemed to be that of an inequality of development either in bulk or elasticity of certain muscles, those affected having either, as it were, lagged behind the skeleton or become fixed in a state of toxic contraction.

Hofer says that the spinal curvature is caused by the growth of a single vertebra. The cause is possibly infection in the periosteum of the vertebra.

LETTERS USED.

a.—Larva.
ab.—Abdominal.
ant.—Anterior.
ap.—Aperture.
apon.—Aponeurosis.
b.—Brown, brown body.
bk.—Black.
bl.—Blood.
bl. sp.—Blood space.
bn.—Bone.
bs.—Boss.
bv.—Blood-vessel.
c.—Cyst.
ca.—Cavity.
cap.—Capillary.
ce.—Cellular cortex.
ch.—Chamber.
cn.—Cone.
col.—Columnar body.
con.—Concavity.
cr.—Crystal.
ct.—Connective tissue.
cx.—Convex side.
d.—Derma.
dinsp.—Dorsal interspinous bone.
dl.—Decayed liver.
dp.—Dried pus.
dr.—Dark red.
dsp.—Dorsal spine.
e.—Healed edge.
ech.—Empty chamber.
ep.—Epithelium.
f.—Fibre : fibrous layer.
fa.—Free larva.
ff.—Fatty fin.
fr.—Fin-ray.
ft.—Fat.
g.—Green.
gp.—Group of cells.
gr.—Groove.
h.—Hilum.
hae.—Hæmal spine : hæmal arch.
is.—Isolated bodies
k.—Kidney.
l.—Liver.
la.—Larva.
lal.—Lateral line.
lb.—Lobe.
lg.—Ligament.
li.—Line.
lu.—Lumen.
M, m.—Muscle.
me.—Mesentery.
n.—Nest of cells.
ne.—Nerve.
neu.—Neural spine : neural arch.
no.—Notochord.
og.—Oil globule.
op.—Opaque.
ov.—Ovum, ovary.
p.—Pigment.
pa.—Parasite.
per.—Peritoneum.
post.—Posterior.
r.—Rib.
rt.—Root.
s.—Swelling of capillary.
sk.—Skin.
sp.—Spongy tissue.
spo.—Sporozoon.
sr.—Secreting region.
swbl.—Swim-bladder.
t.—Tuber.
th.—Thallus-like body.
tl.—Thickened lip.
tn.—Thin lip.
tr.—Translucent.
tu.—Tumour.
v.—Vessel.
va.—Vacuole.
ver.—Vertebra.
w.—Wall of capillary.
wr.—Wrinkles.
y.—Yellow cells.
xy.—Letters to indicate the line of measurement.

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EXPLANATION OF PLATES.

PLATE I.

All the figures are of *Dokus adus*, parasite of haddock (*Gadus æglefinus*).

Fig. 1. Part of cyst lying between muscle fibres. Enlarged.
,, 2. Cyst lying among muscles from haddock, 38cm. long. Enlarged.
,, 3. ,, ,, ,, portion further enlarged.
,, 4. Larvæ. Enlarged.
,, 5. Cyst from haddock, about 43 cm. long. Enlarged.
,, 6. Section of cyst in muscles. Enlarged.
,, 7. Spotted haddock, about 39 cm. long. Reduced.
,, 8. Detached chamber of cyst. Enlarged.
,, 9. Chamber of cyst. Enlarged.
,, 10. Larva from Fig. 6. Enlarged.
,, 11. A cyst extracted from among the muscles. Enlarged.
,, 12. A branched larva from Fig. 6. Enlarged.
,, 13. Theoretical diagram of formation of cyst, first stage of Fig. 175.
,, 14. Detached large chamber of cyst. Enlarged.
,, 15. Larva in two chambers. Enlarged.
,, 16. Appearance of cyst in muscles of haddock, about 43 cm. long. Enlarged.
,, 17. Larva, ·1 mm. long, from kidney. It is the larva *p*. Fig. 19. Enlarged.
,, 18. Cyst from kidney. Enlarged.
,, 19. ,, ,, Enlarged. Size, x-y, ·6 mm.
,, 20. Enlarged capillaries with larvæ of parasite attached to the outside of cyst in muscles. Enlarged.
,, 21. Parasite in kidney. Empty chamber measuring ·12 mm. in diameter. Enlarged.
,, 22. Branched capillary with larvæ of parasite in muscles. Larva, ·07 mm. long. Enlarged.
,, 23. Branched larva observed in kidney. Enlarged.
,, 24. Four larvæ which had left the cyst in kidney. Enlarged.
,, 25. Enlarged drawing of larva, *a'*., Fig. 24. Enlarged.
,, 26. Two larvæ in one cyst, kidney. Enlarged.
,, 27. Thick-walled translucent cell. Enlarged.
,, 28. Free-cells observed among the muscles, apart from the cyst. Enlarged.
,, 29. Group of cells (parasite in muscles). Enlarged.
,, 30. Parasite in kidney. Enlarged.
,, 31. Drawing to show the connective tissue coat of the capillary. Enlarged.
,, 32. Dark-brown body (*b*.) and little green granules (*g*.) observed close together, and detached from any parasite in the tissue of the infected kidney. Enlarged.
,, 33. Dark-brown bodies in infected kidney. Enlarged.
,, 34. Enlarged drawing of evacuated cyst in Fig. 30.
,, 35. A branched larva in the muscle. Enlarged.
,, 36. Small columnar body in muscle. Enlarged.

PLATE I.

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PLATE II.

Fig. 37. *Tetrarhynchus erinaceus*, Van Beneden.
,, A. Cyst in muscle of *Sebastes marinus*.
,, B. ,, ,, larva removed from cyst.
,, C. ,, ,, a larva partly extended. Nat. size.
,, D. ,, ,, ,, sketch of hooks on one of the horns.
,, 38. Hump-backed cod, male, 87 cm. long. Cyst found in kidney. Enlarged.
,, 39. Tusk (*Brosmius brosme*). Tubes of diseased kidney. Enlarged.
,, 40. Hump-backed cod, female, 54 cm. long. Cyst found in kidney. Enlarged.
,, 41. ,, ,, ,, ,, ,, ,, ,,
,, 42. ,, ,, ,, ,, ,, ,, ,,
,, 43. *Zoarces viviparus*, section of infected swollen muscle. Enlarged.
,, 44. *Brosmius brosme*. Tumour, about natural size.
,, 45. Cod (*Gadus callarias*), fillet, with holes in muscle. Reduced.
,, 46. *Brosmius brosme*, infected kidney. Tubules with spore-like bodies (? parasite) attached.
,, 47. *Zoarces viviparus*. Part of infected muscle, enlarged further than in Fig. 43.
,, 48. Cod, fillet. Tumour. Infected muscle shown shaded.
,, 49. Cod, diseased kidney. Tubers on tubes of kidney. The largest (x.) measured $1{\cdot}7 \times 1{\cdot}5$ mm. Enlarged.
,, 50. *Brosmius brosme* Tubules of diseased kidney with spore-like bodies *sp.* (? parasite) attached. Enlarged.
,, 51. Ling (*Molua molva*). Tumours in peritineum. Reduced.

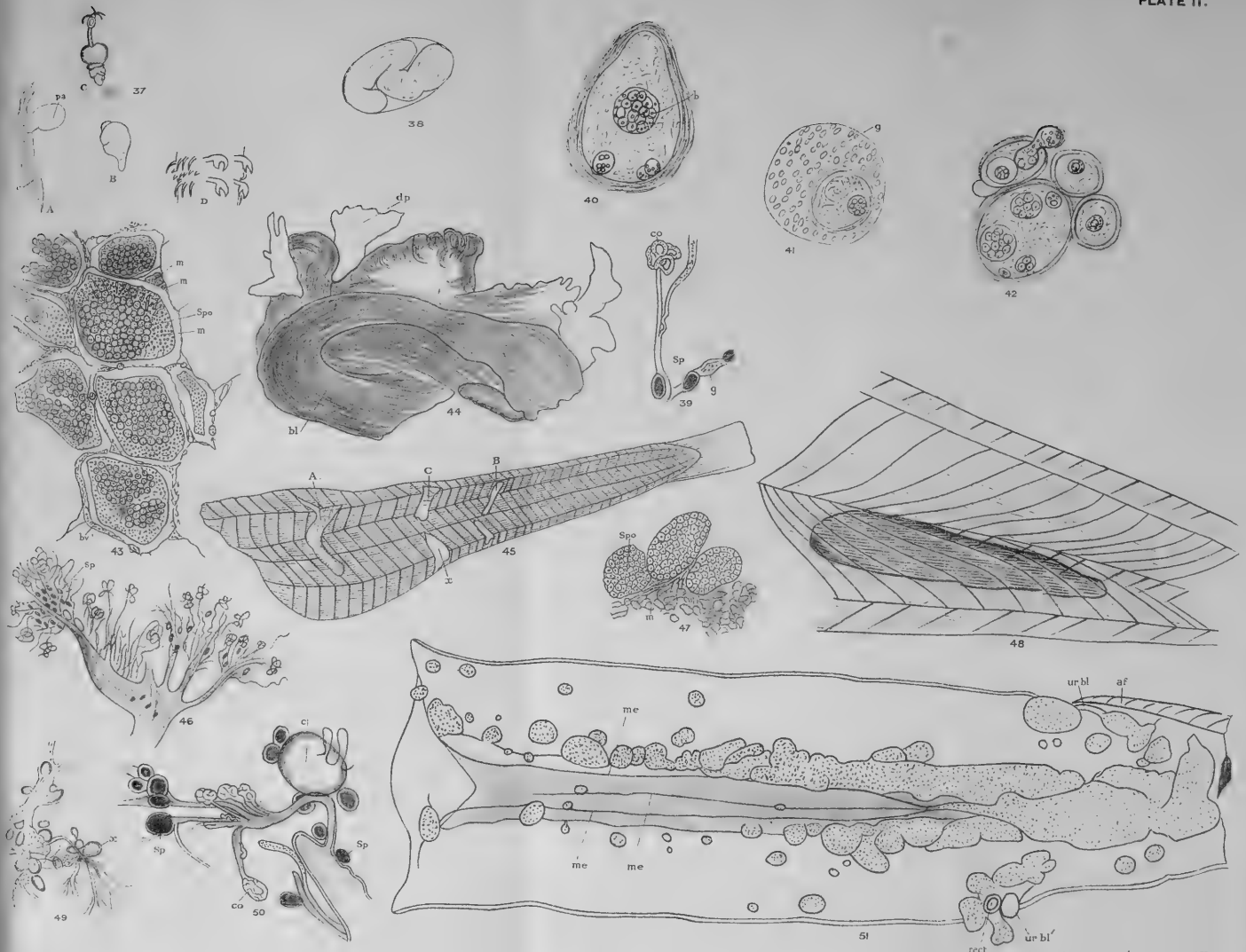

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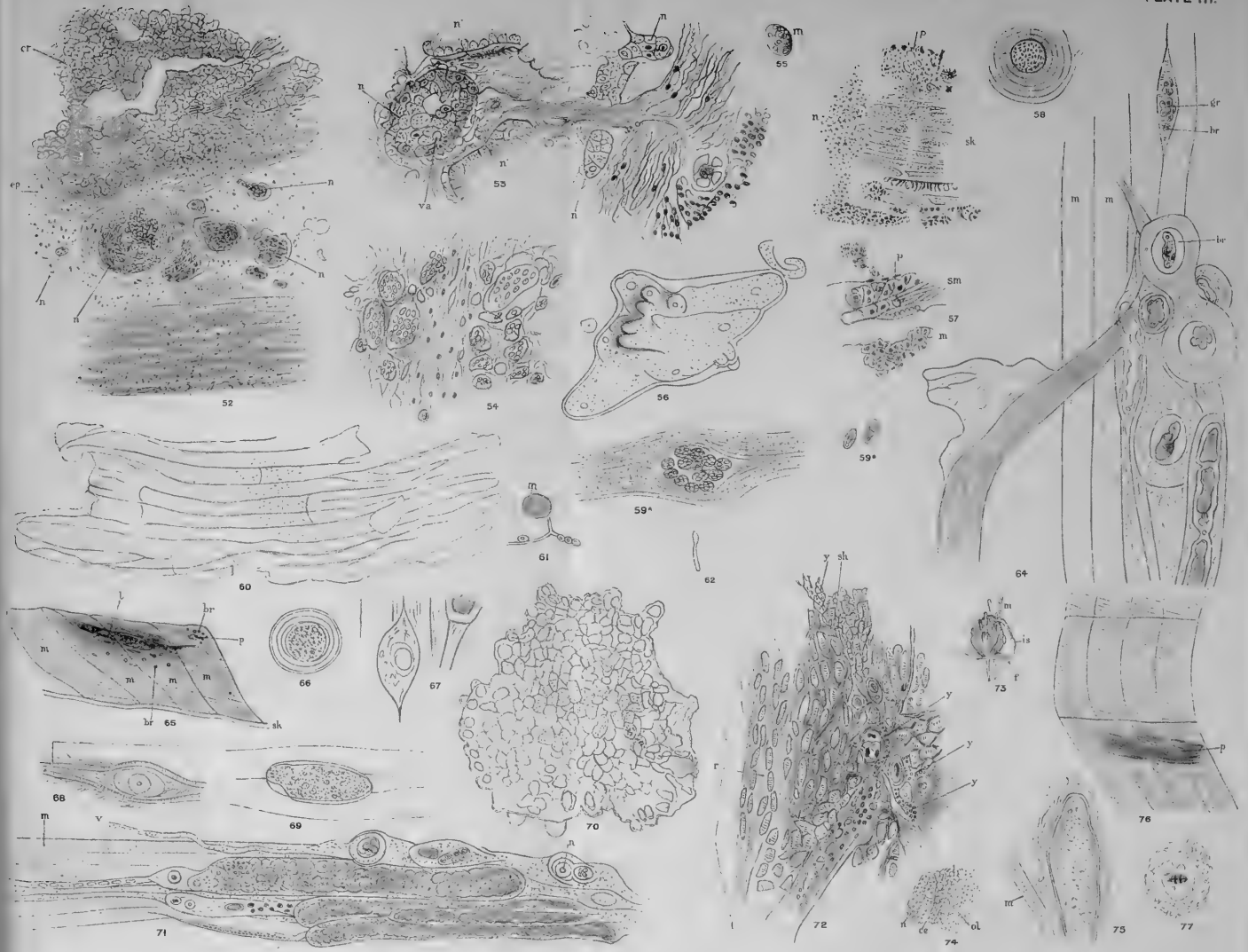
PLATE III.

FIG. 52. Cod, section of cancerous tumour on urinary bladder. Enlarged.
,, 53. *Anarrhichas lupus.* Section of cancerous tumour. Enlarged.
,, 54. Cod, Section of Angioma. Enlarged.
,, 55. Plaice (*Pleuronectes platessa*), external ulcer, section of diseased muscle. Enlarged.
,, 56. Cod, brown parasite in muscles, 1·1 × ·55 mm. Enlarged.
,, 57. Plaice, external ulcer, section. Enlarged.
,, 58. Humpty cod, green spore-like body found in one of the diseased joints of vertebral column. Enlarged.
,, 59A. Catfish (*Anarrhichus lupus*). Tumour in muscles. Sporozoon in muscle fibre. Enlarged.
,, 59B. Do. do. Drawings of spores. Enlarged.
,, 60. Cod, brown parasite in muscle. Enlarged.
,, 61. Plaice, external ulcer, blood-vessel and section of normal muscle. Enlarged.
,, 62. Catfish. Tumour in muscles. Swollen white muscle fibre. Nat. size.
,, 64. Cod, drawing of a small part of the green parasite (*Roles trelis*) in muscles. Enlarged.
,, 65. Cod, green parasite in muscles.
,, 66. Humpty cod. Green spore-like body found between abnormal vertebræ. Enlarged.
,, 67. Cod, green parasite in muscles, allied to Fig. 64. Enlarged.
,, 68. ,, ,, ,, ,, Enlarged.
,, 69. ,, brown parasite, ·57 × ·22 mm. Enlarged.
,, 70. ,, section of a brown parasite. Enlarged.
,, 71. ,, green parasite in muscles. The nucleus (*n.*) is colourless. Enlarged.
,, 72. Cod, section of portion of a green parasite in muscles. Enlarged.
,, 73. ,, brown parasite—an amber-coloured ball.
,, 74. ,, green parasite, quashed capsule. Enlarged.
,, 75. ,, green parasite in muscle. End of shoot in an investment made of connective tissue. Enlarged.
,, 76. Cod, green parasite in muscles.
,, 77. ,, ,, ,, ,, Capsule found among the muscles. Enlarged.



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F

PLATE IV.

FIG. 78. Cod, diseased liver, section across anterior portion.
,, 79. ,, ,, ,, body observed floating in the green fluid. Enlarged.
, 80. ,, ,, ,, ,, ,, ,, ,, ,, ,,
,, 81. ,, ,, ,, tuberous growth attached to vessels. ,,
,, 82. ,, ,, ,, solidified. *st.*=strand of normal liver tissue.
,, 83. Cod, diseased liver (Fig 78). Dark green spore from green fluid. Enlarged.
,, 84. Cod, diseased liver, colourless ovum, about ·1 mm. in diam. It is drawn to the same scale as Fig. 92.
,, 85. Cod, diseased liver. Egg containing green cell, *g*. Enlarged.
,, 86. ,, ,, ,, ,, ,, green nucleated cells, *g*. Enlarged.
,, 87. Cod, diseased liver. Spore from egg, *x*., Fig. 92. Enlarged.
,, 88. ,, ,, ,, Bright green bodies observed in the green fluid. Enlarged.
,, 89. Cod, diseased liver. Dark amber body found in the green fluid. The drawing shows its apparent size with Obj. 4 mm.
,, 90. Cod, diseased liver. Cells which have escaped from the ova. Enlarged.
,, 91. Plaice with deep ulcer on its back. Reduced.
,, 92. Cod, diseased liver (Fig. 78). Portion of a vessel snipped off close to a mass of tubers. Ovum, *y*. is ·45 mm. in diameter. Enlarged.
,, 93. Plaice with flattened external tumour (*cp*. Fig. 96).
,, 94. Cod, pendulous tumour attached to the rete mirabile of the swim-bladder. Some of the corpuscles in the fluid. Enlarged.
,, 95. Lemon Sole (*Pleuronectus microcephalus*). External tumour. Some of the corpuscles from the fluid in tumour (*cp*. Figs. 100 and 102). Enlarged.
,, 96. Plaice with flattened tumour (Fig. 93). Section of body and tumour.
,, 97. Cod, pendulous tumour attached to the rete mirabile of the swim-bladder. Slice of tumour, about natural size.
,, 98. Cod, pendulous tumour attached to rete mirabile of swim-bladder $\times \frac{1}{2}$.
,, 99. Porbeagle Shark (*Lamna cornubica*). Section through external tumour.
,, 100. Lemon Sole (*Pleuronectes microcephalus*). Section of external tumour. *cp*. Figs. 95, 102. Enlarged.
,, 101. Cat-fish, *Anarrhichas lupus*. Diagram of tumour in muscles.
,, 102. Lemon Sole with tumour on blind side. About $\frac{1}{2}$, *cp*. 95 and 100.
,, 103. Skate (*Raia*). Mesenteric cyst. About nat. size.
,, 104. Humpty Cod, 14 inches, (35) long, dorsal view reduced.

PLATE IV.

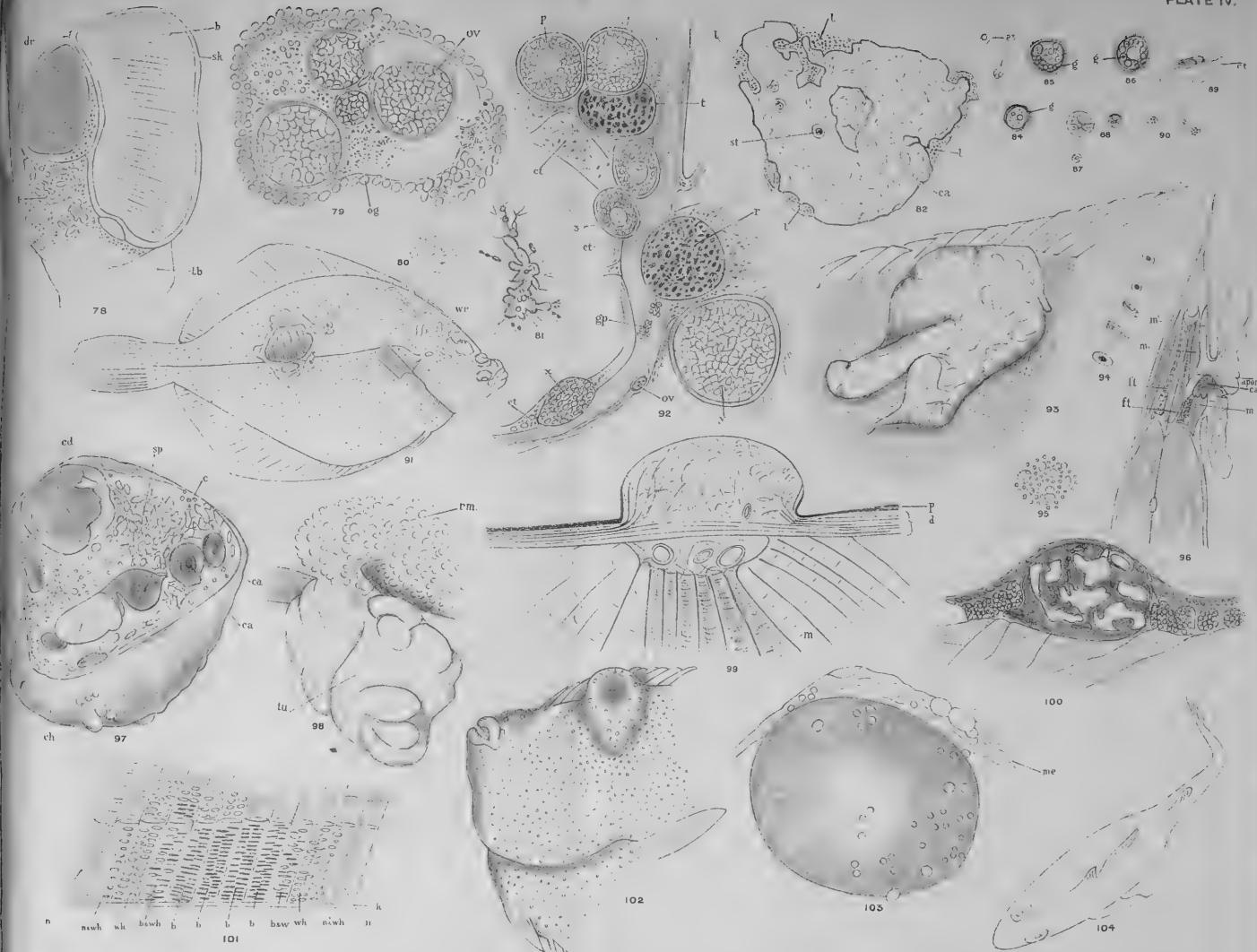

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PLATE V.

FIG. 105. Salmon (*Salmo salar*). Three blood clots on the dorsal spines of the vestebræ below the fatty fin.

,, 106. Salmon, discoloured muscle fishes. Enlarged.

,, 107. ,, section of body at about the middle of the length of the abdomen, to show the discoloured (red) flesh. Reduced.

,, 108. Salmon, section of body at the beginning of the first dorsal fin to show the extent of the discoloured flesh. Reduced.

,, 109. Salmon, drawing of brown-muscle fibre. Enlarged.

,, 110. Salmon, diseased fatty fin with openings *ap.* into the interior.

,, 111. Salmon, pink muscle fibres. Enlarged.

,, 112. Porbeagle Shark (*Lamna cornubica*), tumour on exterior of body. *cp.* Fig 99. *Nat. size.*

,, 113. Tusk (*Brosmius brosme*), tumour attached to kidney. Tube of kidney. Enlarged.

,, 114. Saithe (*Gadus virens*), tumour in abdomen. Section. (Fig. 116). Enlarged.

,, 115. Saithe (*Gadus virens*), tumour; drawing of spore on edge of tumour. Enlarged.

,, 116. Saithe (*Gadus virens*), showing the tumour projecting through the intercostal space into the abdominal cavity. Figs. 120, 122.

,, 117. Cod. Tumour. Approx. nat. size.

,, 118. Saithe. Tumour attached to kidney. Vertebræ mal-formed by the tumour.

,, 119. Cod. Tumour (Fig. 117), portion.

,, 120. Saithe. Tumour in dorsal region of abdominal cavity; displaced ribs (Fig. 116).

,, 121. Ling (*Molua molva*). Section of tumour in periteneum and wall of abdomen.

,, 122. Saithe. Tumour in dorsal region of abdominal cavity, seen from dorsal side (Fig. 116).

,, 123. Ling. The two fibrous layers of the lining of the abdominal cavity.

,, 124. ,, Tumour in peritoneum, section.

,, 125. ,, ,, ,, ,, hole in the fibrous layer from root (*rt.*) of tumour (Fig. 124).

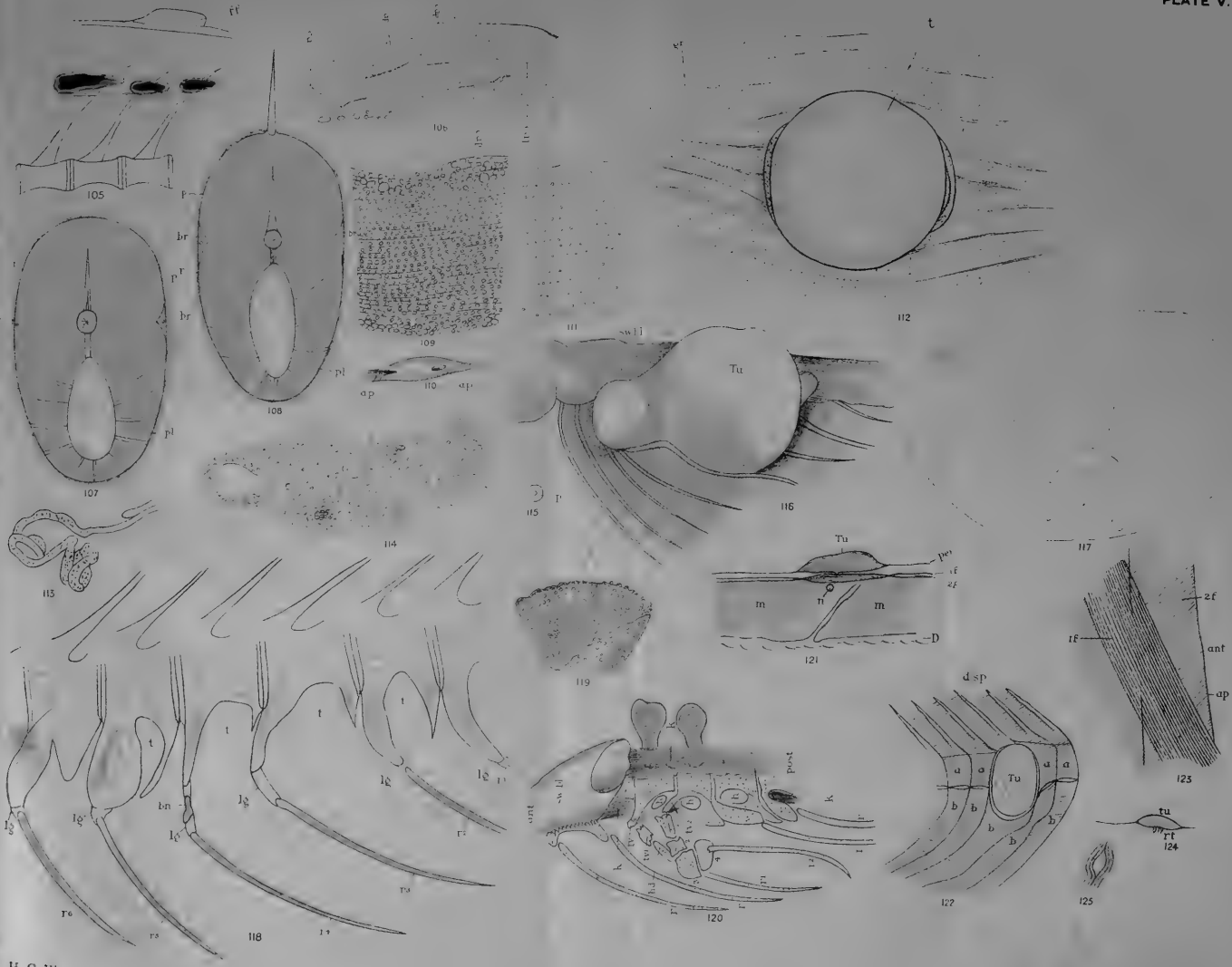

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PLATE VI.

FIG. 127. Gut which had been perforated by a bone.
,, 128. Humpty cod, 44 cm. long. Reduced.
,, 129. Cod. Pimpled skin. Drawing to show white dendritic region in the spleen. About natural size.
,, 130. Cod. Diagram of section of normal vertebra.
,, 131. ,, Bony tumour attached to the vertebral column, seen from the left side. × about $\frac{1}{2}$.
,, 132. Cod. Pimpled skin; surface view of skin (Fig. 129).
,, 133. *Tetrarhynchus megacephalus*, Rud., from lining of abdominal cavity of Iceland saithe. Natural size after preservation.
,, 134. *Echinorhynchus acus* attached to peritoneum of saithe? Natural size after preservation.
,, 135a. Cod. Section across a vertebra.
,, 135b. ,, Bony tumour, seen from right side (Fig. 131).
,, 136. Humpty cod (Fig. 128). Anterior surface of 18th vertebra.
,, 137. ,, ,, ,, Vertebra No. 22.
,, 138. ,, ,, ,, ,, ,, 14. Posterior surface. Approximately natural size.
,, 139. Salmon. Tumour from pharynx. Nat. size.
,, 140. Cod. Bony tumour (Fig. 131). Section in horizontal plane. About natural size.
,, 141. Humpty cod (Fig. 128). Vertebra No. 7, anterior end. Approximately natural size.
,, 142. Humpty cod (Fig. 128). Vertebra No. 5, anterior end.
,, 143. ,, ,, ,, Vertebræ No. 15, 16, and 17, longitudinal section. About natural size.
,, 144. Humpty cod (Fig. 128). Vertebra No. 22, side view. Nat. size.
,, 145. Gut that had been perforated (Fig. 127). Aperture showing the bone projecting. Enlarged.
,, 146. Humpty cod (Fig. 128). Vertebræ Nos. 4, 5, 6, and 7, seen from below. Approximately natural size.
,, 147. Humpty cod (Fig. 128). Vertebræ Nos. 15, 16, 17, 18, and 19.
,, 148. Salmon. Bone found stuck in the wall of the stomach of a salmon About natural size.
,, 149. Humpty cod (Fig. 128). Vertebral column. Reduced.
,, 150. Gut perforated by a bone. Optical section of injured gut. (*cp.* Figs. 127, 145).
,, 151. Cod. Section of a vertebra.

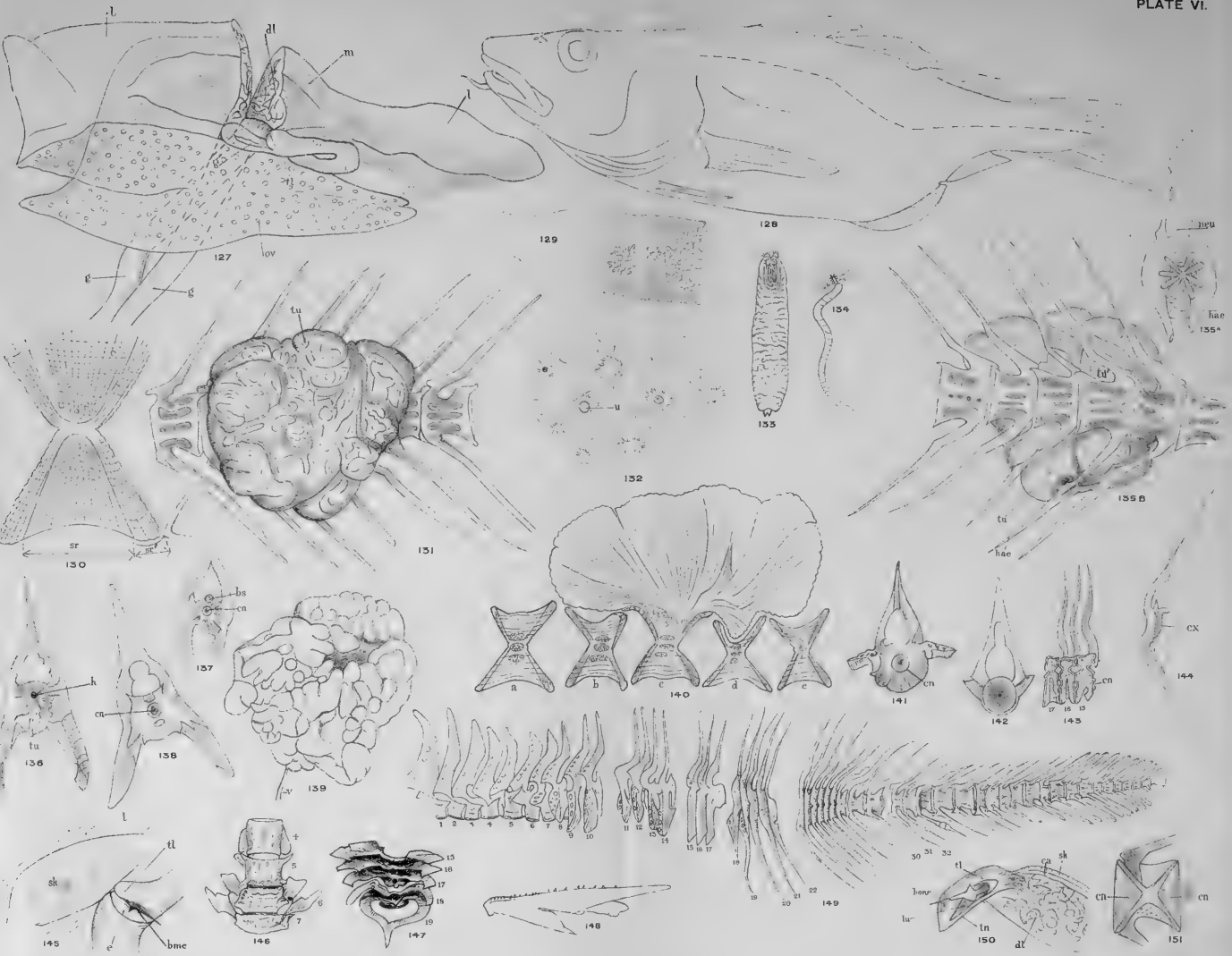

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PLATE VII.

Fig. 152. Saithe. Section of tumour. Reduced.
,, 153. ,, (Fig. 52). Narrow strip of fat-infiltrated muscle ("oil"): side view. (Fig. 152).
,, 154. Saithe (Fig. 52). Narrow strip of fat-infiltrated muscle, surface view.
,, 155. ,, ,, Section of fat-infiltrated muscle-bundle.
,, 156. Cod. Normal kidney. Spore-like body (·07 mm. in diameter), seen at *sp.* in Fig. 157.
,, 157. Cod. Normal kidney. Tissue enlarged.
,, 158. Saithe (Fig. 152). Muscle fibre partly laden with fat drops.
,, 159. Deformed cod—spinal curvature. Dorsal view of the deformed part of the vertebral column.
,, 160. Saithe (Fig. 152). Muscle fibre swollen with fat drops. Enlarged.
,, 161. ,, ,, Section across fish to show the parts (shaded) of muscle infiltrated with fat drops.
,, 162. Deformed cod (spinal curvature), 35½ inches (88 cm.) long. Reduced.
,, 163. ,, ,, ,, ,, Side view of vertebræ, Nos. 10-21.
,, 164. Saithe. Healed tumour. Semi-diagrammatic drawing.
,, 165. Sea trout (*Salmo trutta*) larva with bent notochord. Enlarged.
,, 166. Cod (fig. 162). Vertebræ Nos. 11 and 12, seen from below.
,, 167. Deformed cod (spinal curvature). Run of ventral column seen from the side.
,, 168. Deformed cod (Fig. 167). Run of ventral column seen from above.
,, 169. Cod. Diagram of tumours—? fat-infiltrated portions of muscle.
,, 170. Deformed cod (Fig. 162). Disease of cornea.—Pterygium.
,, 171. ,, ,, (Spinal curvature). Fractured vertebra,
,, 172. ,, ,, (Fig. 162). Section thin diseased cornea (Fig. 170).

PLATE VII.

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PLATE VIII.

ALL OF *Dokus adus.*

FIG. 173. Parasite in the kidney of haddock. Of the same magnification as Figs. 174 and 177.

,, 174. Cyst with many-branched parasite in the kidney of haddock. Of the same magnification as Figs. 173 and 177.

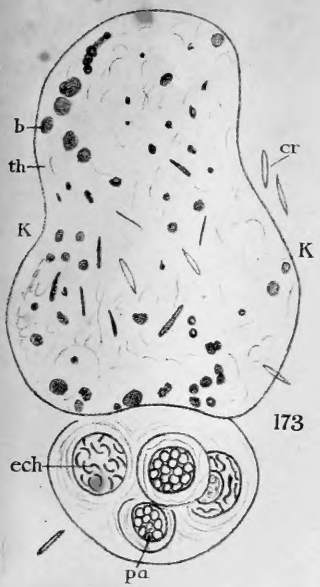
,, 175. Theoretical diagram of the formation of the cyst. Stage subsequent to that shewn in fig. 13.

,, 176. Parasite in the muscle of haddock. Enlarged.

,, 177. Cyst with large larvæ in the kidney of haddock. Larva, *a*, was about ·12 mm. long. Of the same magnification as Figs. 173 and 174.

,, 178. Parasite in the muscle of haddock. Isolated body. ·2 mm. long. Enlarged.

,, 179. Cyst in the muscle of haddock, teazed apart. Enlarged.



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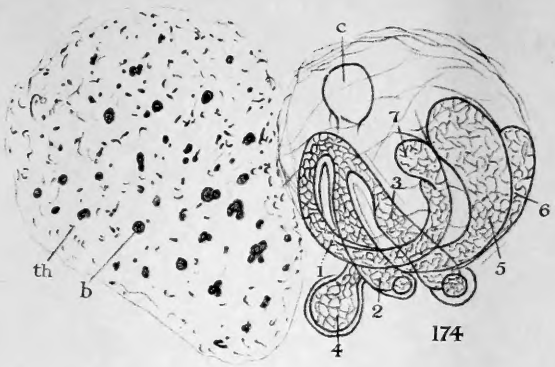

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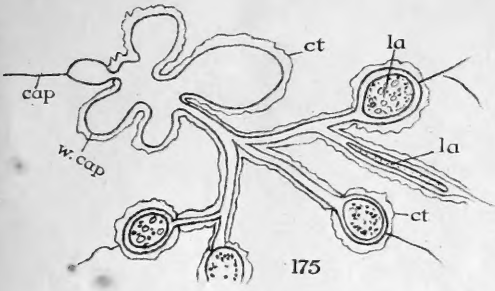

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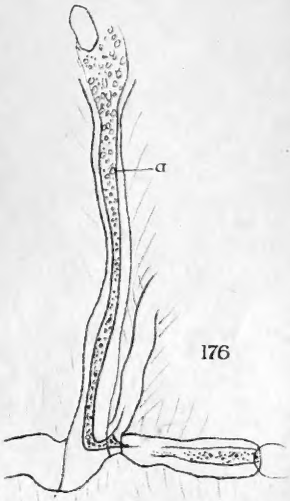

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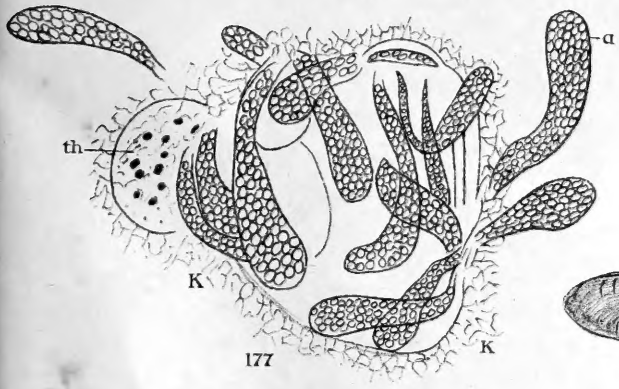

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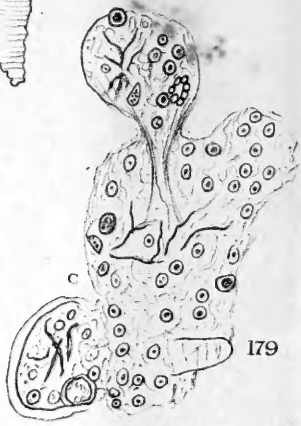

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